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HIGH SCHOOL SCIENCE AND CONSUMER ECONOMY

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When a teacher talks this way to a class of high school students, there is little chance of inattention. "Once there was a very clever man who announced to the world that he had discovered a cure for rheumatism and high blood pressure. He sold thousands of bottles of the clear, tasteless liquid, and people were careful to follow the directions on the bottle—'not more than one teaspoonful in a glass of hot water; morning, noon, and night.' They paid a high price for each bottle, too. Finally, a group of chemists analyzed the liquid. No wonder it was clear and tasteless—it was one hundred per cent water! How would *you* like to pay a dollar a bottle for ordinary water?"

The class registers disapproval, and the teacher continues. "You girls have undoubtedly heard of beauty clays and beauty masks. You know that they are expensive. But did you know that you could easily make your own—not that it would do your skin any good—for about ten cents a pound? You simply need to buy at a druggist's some kaolin, glycerin, and perfume, and mix the three into a paste. There are dozens of such frauds on the market. Some are harmless except for the money wasted; some are definitely harmful because of the chemicals they contain. You can find examples not only in cosmetics and medicines, but in clothing, canned foods, house furnishings, soaps, and the like."

About this time, there will be hands waving for recognition.

Jack says, "I had an example of cheating just yesterday. My new shirt was washed for the first time, and did it shrink! But my mother bought it especially because it was marked 'pre-shrunk.'" Then Ann contributes this, "Did you ever notice what a tiny amount of medicine you get sometimes even though the package looks big? And the bottle has such thick glass sides." Then Bill and Joan and Dick and all the rest add their experiences. And the desire for a Unit of Work on the subject is evident.

Consumer Economy is always a popular subject with high school pupils. By this time, most of the boys and girls have begun to do their own buying of school supplies, cosmetics, drugs, clothing, etc. And no one is more determined to get his money's worth than a teen-ager. All he needs is some accurate information and a little practical experience. In these war days, consumer economy is important for everyone, young and old alike; but adults for the most part are slow to change their ways. Thus, in the long run, education of high school students for intelligent buying is quicker and more effective.

Such a Unit functions most successfully when outlined by teacher and pupils into several fields, each to be covered by a small group of students. The groups work independently, after general instructions have been given, gathering information and preparing presentations for the class. Some convenient groups are these: Cosmetics, Medicines, Soaps, Clothing, Foods, Home Furnishings, Automobiles, etc.

A suggestive outline for group procedure is given to each leader.

1. List of types of fraud practiced in the field
 - a. actual falsification
 - b. deceiving labels—as to weight and contents, tiny print, long chemical names, etc.
 - c. skimping on materials used, size of container, etc.
 - d. seals and guarantees of no value
 - e. extravagant and unjustified claims
 - f. excessive price for the contents
 - g. endorsements by doctors, scientists, movie stars, athletes, etc.
2. Examples of advertisements from magazines and radio.
3. Examples of products-labels, wrappings, etc.
4. Group's rating of product on basis of own tests, experiments, group-made products, field investigations in stores, opinions of pharmacists and doctors in town, printed statements of recognized authorities, etc.
5. Glass presentation of posters, sample labels, products made by group, reports from field research; ending with group recommendation for consumer-buying in the field.

Some references which are of value and which can be used easily by high school students are these:

- Take Care of Yourself*—Jerome W. Ephraim—Simon and Schuster, N. Y., 1937
How to Get your Money's Worth—Ruth Brindze—Garden City Pub. Co., N. Y., 1937
Popular Practice of Fraud—T. S. Harding—Longmans, Green, and Co., N. Y., 1935
Your Money's Worth—S. Chase and F. J. Schlink—Macmillan Co., N. Y., 1940
Counterfeit—Arthur Kallet—Vanguard Press, N. Y., 1935
Johnny, Get Your Money's Worth—Ruth Brindze—Vanguard Press, N. Y., 1938
Skin Deep—M. C. Phillips—Vanguard Press, N. Y., 1934
Stretching Your Dollar in Wartime—Brindze—Vanguard Press, N. Y., 1942
 Consumers Research Bulletins, Washington, New Jersey
 Consumers Union Bulletins, New York City
 Publications of American Medical Association, Chicago
 Publications of Institute for Consumer Education, Stephens College, Columbia, Missouri

Working with this outline and under the guidance of the teacher, the *Cosmetics Group* may be expected to accomplish these things:

1. A long list of extravagantly advertised products found in the popular magazines.
2. A collection of labels, wrappings, containers, bottles, of these products—found at home, in stores, etc.
3. A list of comparisons—advertisements with labels, etc.
4. Statements of authorities on these products: from reference books and pamphlets, from local doctors, from pharmacists, etc.
5. Exhibit of attractively bottled and correctly labelled cosmetics made from the following recipes or other equally safe and inexpensive recipes. Cost.

Astringent—Witch Hazel

Talcum Powder—Mix about 6 drops of U.S.P. lavender with a small amount of Italian talc, until smooth. Then add it to the remainder of a pound of Talc, or use purified talcum powder U.S.P., instead.

Freckle Remover—Use peroxide. Or mix lemon juice with 15% alcohol, 1% glycerin.

Nail Polish Remover—Ethyl acetate

Nail Bleach—Lemon juice best. Or citric acid and water in proportions of 95 water to 5 citric acid.

Hand Lotion—Fill a pint bottle half full of water. Add one level teaspoonful of powdered gum tragacanth and four tablespoonfuls of glycerin. Shake this well and let it stand for twelve hours. Then add the other half-pint of water and shake again. Few drops of perfume and harmless coloring can be added if desired.

Shampoo for Mild Dandruff—Tincture of Green Soap U.S.P.

Deodorant—Mix 3 grams benzoic acid with 25 grams of vanishing cream. Or, for stronger action, mix two above ingredients and add 3 grams of powdered boric acid.

6. Group Report to Class

- a. On worth of com'l products, cost, values of contents; illustrated with advertisements, labels, wrappings, etc.
- b. On worth of group-made products, cost, value of contents to consumer; illustrated by demonstrations of these cosmetics by group-members.
- c. Group judgment on the subject of consumer economy in the cosmetics field.

The *Home Furnishings Group* may find these recipes helpful in their research.

Cleaning Fluid—carbon tetrachloride

Fly-Spray—Add two ounces of pyrethrum powder to one quart of kerosene. Allow the mixture to stand for a time, then pour off the clear liquid at the top and use as a spray.

Floor Wax—While working, keep all flame away. All melting should be done over boiling water, so several supplies of boiling water will be necessary. Place six ounces of carnauba wax and six ounces of ceresin wax in a tin about the size of a pound coffee tin. Place this in the boiling water, stirring contents until they are liquefied. This will be in about thirty minutes. Then pour in 9 ounces of turpentine and 9 ounces of non-leaded gasoline, put the tin in cold water, and again stir until wax cools to a paste.

Cleansing Powder—for grease spots, use fuller's earth.

Cleanders and Polishers—for porcelain, plated silver, enamel, metal surfaces, make a paste with water of whiting, sometimes called Spanish white.

Window Cleaners—1 part ammonia to ten of water. In cold weather, kerosene on a soft cloth may be better.

Furniture Polish—Mix equal parts of turpentine, linseed oil, and vinegar. Apply with a damp cloth.

The *Medicines Group* may find these recipes of value:

Toothpowder—Add a little bicarbonate of soda to a pound of precipitated chalk U.S.P. Flavor with a few drops of oil of peppermint.

Mouthwash—two teaspoonsful of salt to a quart of water. Shake.

Sleep-inducers—Drink a glass of warm milk; flavored with chocolate and accompanied by a graham cracker, if desired.

Antiseptics—Boil some water ten minutes. Add enough Epsom salts to make a solution so saturated that some of the salts will remain on the bottom of the bottle after twenty-four hours standing.

Or make a saturated solution of boric acid crystals.

Most of these materials will be easily available in a high school laboratory or in even a small-town drugstore or hardware store. All are of medium or low price and the resulting products are "safe and good," according to two pharmacists consulted.

GEOMETRY OF THE EARTH'S SURFACE

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People have been awakened with a jolt recently to the fact that they no longer can consider themselves merely as local beings, the outside world being of no direct interest to them. What is this fantastic report that the shortest distance from New York City to Chungking passes right over the north pole? Or that the shortest route from Tokyo to San Francisco passes within 400 miles of Dutch Harbor, and the closest point on this route is 1800 miles from Pearl Harbor? Aren't Maine and the State of Washington the most northern points of the United States? They may be farthest "up" on many maps but not the farthest north. Observe several types of maps carefully. Then look at a globe. Sometime ago Congress required by law that "public lands shall be divided by north and south lines, run according to the true meridian, and by others crossing them at right angles so as to form townships six miles square." Congress can no more put the foregoing legal law into effect than it can repeal the law of gravity.

In order to answer the questions and to understand the statements mentioned above, one must make a study of the spherical surface in general and of the surface of the earth in particular. Now having done this, one would not be satisfied without examining the motions of the earth in the solar system. What causes day and night? the seasons? A third step, very naturally, is to combine these two studies and so be able to find latitudes and longitudes, very important is this world of swift motion. At least it may help us to understand some of the problems of navigation

The first of these three problems only, will be treated here. A fair knowledge of solid geometry is presupposed. So let us proceed with *THE*

MEASUREMENT OF THE EARTH'S SURFACE

To locate a point uniquely in a system of one dimension, i.e., on a line, one number must be known. See Fig. 1A. To locate a point uniquely in a system of two dimensions, i.e. on a surface, two numbers must be known. See Fig. 1B. To locate a point uniquely in a system of three dimensions, i.e., in space, three numbers must be known. See Fig. 1C. The axes in question are

a point, two lines, and three planes, respectively. Since the earth is a surface two lines must be used as reference axes and two numbers must be known if we are to designate a definite point thereon. But the location of a point on the earth's surface is not as simple as though it were on a plane surface. The earth is practically a sphere with a radius of about 4000 miles. So the shortest distance between two points on its surface is an arc of a great circle passing through these points; this is a "straight line" of a spherical surface. Other oddities we note about the surface of the sphere are: (1) two straight lines can enclose a surface, (2) perpendiculars to the same line meet, (3) there is no such thing as parallel lines, as defined in plane geometry. This study can be likened to the geometry of Riemann where

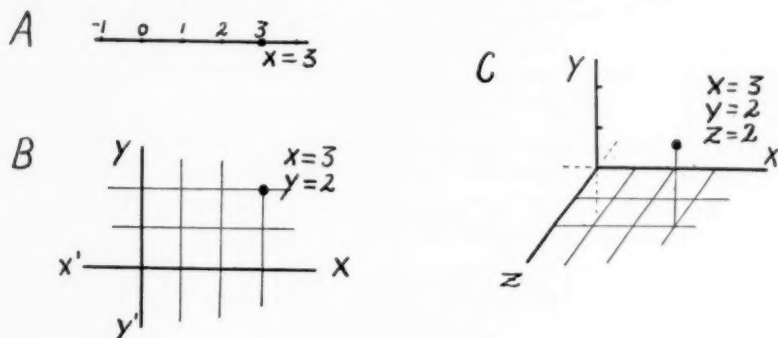


FIG. 1

curvature is positive as contrasted with that of Euclid where curvature is zero (the plane), and of Lobachevsky where curvature is negative.¹

The reference axes of the surface of the earth are the equator and prime meridian—the equator corresponding to the x -axis and prime meridian the y -axis. The equator is a great circle of the earth, dividing it into the northern and southern hemispheres. Perpendicular to the plane of the equator and passing through its center is a straight line called the axis of rotation, or just the axis. See NS of Fig. 2. Since NS is a diameter of the earth, any plane containing it determines a great circle which is called a meridian circle. One half of one of these meridian circles, called the prime meridian, extends from the north pole to the south pole and passes through Greenwich, England.

¹ Two excellent references on this subject of Non-Euclidian Geometry are: Kasner and Newmann, *Mathematics and the Imagination*, Chapter IV, "Assorted Geometries"; Henderson, K. B., "Lessons Non-Euclidean Geometry Can Teach," *Mathematics Teacher*, pp. 73-79, Feb. 1940.

It is used as the axis of reference corresponding to the y -axis in a plane. It intersects the equator at right angles in a point called the origin. The other half of this great circle extending from N to S on the other side of the earth is called the international date line excepting certain deviations around islands designed to avoid the anomaly of inhabitants having two dates at the same instant. Just imagine how awkward it would be to have one foot in Tuesday and the other in Wednesday.

The equator is divided into degrees, 180° west and 180° east, these meeting at T on the international date line. The meridian lines, or lines of longitude, pass across the equator at right angles and at equal intervals. These meridian lines determine the longitude of a place, or angular distance from the prime meridian, the angle being that subtended at the center of the earth, or its equivalent. East longitude is usually denoted as negative and west, as positive.

Planes parallel to the plane of the equator and (of course) perpendicular to the axis determine the "parallels" or small circles of the earth. These are called latitude lines. Latitude is the angular distance of a point north or south of the equator and is measured by the angle subtended at the center of the sphere. North is positive and south negative. See Figure 2. Thus, latitude is measured from 0° at the equator to 90° at the poles. The meridians are used to measure east and west distances while the parallels are used to measure north and south distances—all angular distances, since the coordinates of a point must be given in degrees. So we find the earth at present blocked off with imaginary lines forming a network called the grid.

In addition to all the ordinary parallels there are four special ones which divide the earth's surface into zones. These are the Arctic Circle, Tropic of Cancer, Tropic of Capricorn, and Antarctic Circle. As noted in Figure 2, the angular distances from F to N , D to E , D to G , and H to S are respectively, 23.5° . This is due to the fact that the axis of the earth is tipped 23.5° from the perpendicular to the plane of its elliptical orbit.

Now we are ready to use our knowledge of the earth's grid, some spherical geometry, and a bit of trigonometry. Refer to Figure 2.

To locate a point A , longitude -60° (60°E) and latitude $+50^\circ$ (50°N), we start at L , travel 60° east on the equator to B ($\angle LOB = 60^\circ$), then north 50° on a meridian to A ($\angle BOA = 50^\circ$). A is thus uniquely located. This is farther than tracing the

course from L to C , then to A on the parallel with C . Why? Is $CL=AB$? Is $LB=CA$? CL and AB are both $50/90$ of the polar distance and so are equal. CA and LB are arcs of the same number of degrees but the arcs are not equal.

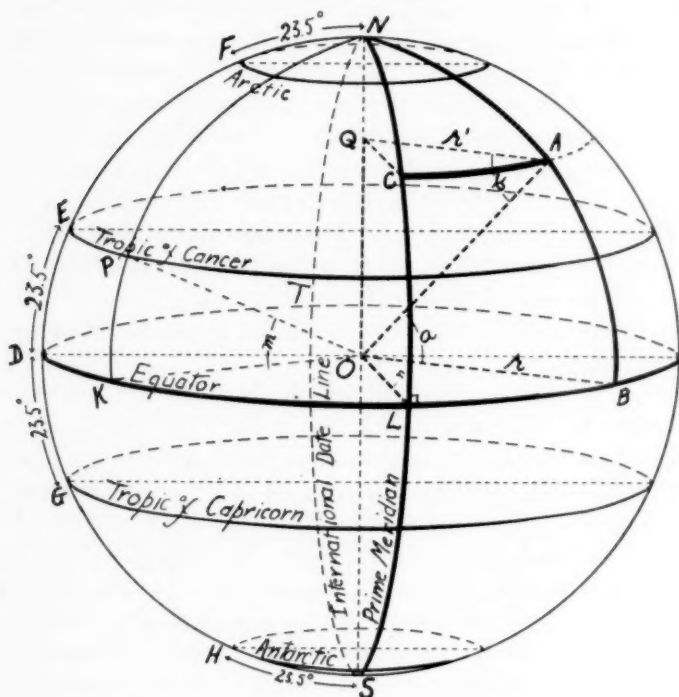


FIG. 2

The problem of finding the distance between two points on the earth divides itself into three cases:

First, the distance between two points on a meridian or on the equator.

Second, the distance between two points measured along a parallel.

Third, the distance between two points lying on a great circle which is neither the equator or a meridian.

The first case is quite simple since we need only to find the numbers of degrees m subtended by an arc such as KP (Figure 2), from the proportion $KP/2\pi r = m/360$, where r is the radius of the earth whose length may be expressed in miles, and solve for KP . Thus,

$$KP = 2\pi r m / 360. \quad (1)$$

The second case is a bit more complicated since the length of a parallel varies with the distance from the equator. To find the

distance along the parallel from C to A whose center is Q , the radius r' of circle Q must be found. Since the horizontal planes ACQ and BLO are cut by the plane ABO it follows that QA is parallel to OB . Thus, $\angle a = \angle b$ and $OA = r$. Thus, $r' = r \cos b$. Since $\angle CQA = \angle LOB = n$, it follows that

$$CA = 2\pi nr' / 360$$

$$\text{or,} \quad CA = 2\pi nr \cos b / 360 \quad (2)$$

from which we observe that the distance between two points measured along a parallel is equal to

$$(\pi r / 180) \cdot (\text{difference in longitude}) \cdot (\text{cosine of latitude}).$$

In the third case we are to find the distance between two points taken at random. See Fig. 3. Let the two points be P_1 and P_2 . Let x_1 and x_2 be their longitudes and y_1 and y_2 be their

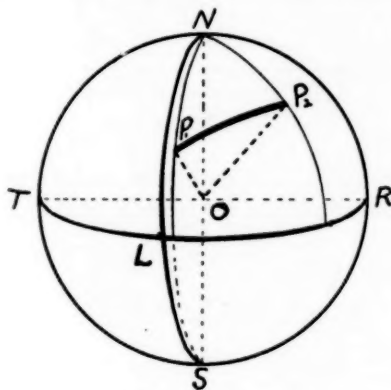


FIG. 3

latitudes, respectively. NLS is the prime meridian and TLR the equator. O is the earth's center and P_1OP_2 the central angle of a great circle through P_1 and P_2 . The formula used is

$$\cos \angle P_1OP_2 = \sin y_1 \sin y_2 + \cos y_1 \cos y_2 \cos (x_1 - x_2). \quad (3)$$

Having found angle P_1OP_2 from this, we proceed as in Case I, in which

$$d = (\angle P_1OP_2 / 360^\circ) (2\pi r). \quad (4)$$

The development of this formula is not presented here but it may be found in any book on spherical trigonometry. Its usual form is

$$\cos a = \cos b \cos c + \sin b \sin c \cos A \quad (5)$$

where a , b , and c are the lengths in degrees of sides P_1P_2 , P_1N , P_2N , respectively, in the spherical triangle NP_1P_2 . In equation (3) the complements of b and c are used, and A , the angle at N , is the difference in longitude.

For those with little experience in trigonometry, choose P_1 and P_2 in order to make $x_1 - x_2$ positive. Then if $x_1 - x_2$ is greater than 90° , say 125° , proceed thus: $\cos 125^\circ = -\cos (180^\circ - 125^\circ)$, or $-\cos 55^\circ$. The rest of the formula will not cause trouble.

Finally, the area of a zone of a sphere $= 2\pi rh$, that is, it is the circumference of a great circle times the height or distance between the planes of the circles. See Figure 2.

To find the altitude, OQ , of a zone between the equator and a parallel, say between LB and CA ,

$$\begin{aligned}\sin b &= OQ/OA \\ OQ &= r \sin a.\end{aligned}$$

Thus the area,

$$\begin{aligned}z &= 2\pi r \cdot r \sin a \\ z &= 2\pi r^2 \sin a\end{aligned}\tag{6}$$

in which r is the radius of the sphere and a the latitude of the parallel. The area of a zone between any two parallels is

$$z = 2\pi r^2(\sin a - \sin a')\tag{7}$$

where a and a' are the latitudes.

Problems

(Use $r = 4000$ miles and consider the surface of the earth only.)

1. Find the length of the equator, the 10th parallel, the 20th parallel, the 30th parallel, etc.
2. What parallel is one-half the equator?
3. State the law that governs the variation of lengths of parallels with respect to their angular distance from the equator.
4. What is the locus of a point with latitude 0° ? 90° ? -90° ?
5. What is the locus of a point equidistant from the poles? from one pole and the equator?
6. A plane flies due east from a point whose coordinates are $(90^\circ, 30^\circ)$ to point $(0^\circ, 30^\circ)$. How far does it fly?
7. A plane flies due east from $(20^\circ, 70^\circ)$ to $(-160^\circ, 70^\circ)$. How far is this? Calculate the *shortest* route between these points.
8. Find the area of a belt (zone) of the globe between the equator and the 10th parallel, the equator and the 20th parallel, etc.
9. The equator and which parallel bound one-half the land in the northern hemisphere?
10. What law governs the variation in area of zones between the equator and successive parallels to the north?

11. A spherical triangle has as vertices $(10^\circ, 0^\circ)$, $(40^\circ, 0^\circ)$, and $(25^\circ, 90^\circ)$. Find the perimeter and area of its polar triangle.
12. Chicago is W-longitude $87\frac{1}{2}^\circ$ and N-latitude 42° . Norfolk, Virginia is W-longitude 77° , N-latitude 37° . Find the distance from Chicago to Norfolk (a) going due south and then due east, (b) going due east then due south. (c) Find this difference. (d) Calculate the direct route. Answers: (a) 934.47 mi., (b) 893.79 mi., (c) 40.68 mi., (d) 663.22 mi.
13. Criticize this statement found in a recent magazine: "If two men should separate at the south pole, one traveling due northeast, the other northwest, which one would reach continental land first?"

This set of exercises brings out two interesting facts concerning our globe. First, the *circles* of latitude from the equator to the poles decrease as the *cosine* of the latitude. Figure 4 shows graphically what this means. $\angle PQR$ is divided into six equal parts. Vertical distances from the arc graph the sine; horizontal, the cosine. The formula for a parallel is

$$c = 2\pi r \cos a \quad (8)$$

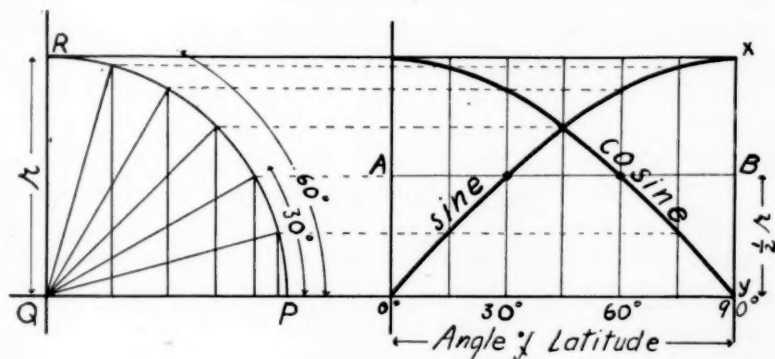


FIG. 4

where c is the circumference of a small circle, r is the radius of the sphere, and a the latitude. Thus, a is the independent variable controlling c . Note that $\cos 60^\circ = \frac{1}{2}$ and thus the length of the 60th parallel is half the length of the equator. The cosine of an angle varies from 1 to 0 as the angle increases from 0° to 90° .

For a second fact, we note that the area of a zone between the equator and any parallel varies as the sine of the latitude. (Equation 6). Here the independent variable again is a controlling z . The sine of an angle varies from 0 to 1 as the angle changes from 0° to 90° . Note that the area bounded by the 30th parallel and the equator is one-half the area of the northern hemisphere. The cosine decreases in value slowly for small angles but rapidly for angles near 90° . Thus the circles near the

poles decrease rapidly as the latitude approaches 90° . The sine increases rapidly for small angles, but slowly for angles near 90° . Thus, from equation (6) we see that the area of zones bounded by a parallel of latitude near 90° increases slowly.

The facts mentioned above should be carefully considered in reading maps. In representing the surface of a sphere on a plane certain distortions occur. The distortions depend upon the method of construction. For example, on a Mercator map in which the meridians and parallels are represented by straight parallel lines, we find distortions in areas except in equatorial regions. This map, however, has one feature which is useful in navigation, namely, two points may be connected by a straight line which corresponds to the rhumb line. This is a curve between the two points which does not change direction.

Among other types of map projections we find distortions in distances, shapes, and directions. Thus, the map chosen for use should belong to the type best adapted to show the relationship to be investigated.

CHEMICAL FORMULATOR

United States Patent No. 2,293,405, issued on August 18, 1942, describes an ingenious device for teaching the formulation of chemical compounds.

In the words of that patent: "Devices of this kind have previously been suggested, but these have either been incomplete in one or more respects, or they have been too complicated and expensive for individual student use.

"It is an object of the present invention to provide a chemical formula indicating device which shall be able to give the names of a great many chemical compounds, as well as the symbols used to indicate them, the valences of the radicals making up the compounds and an indication of compounds which are unknown or of doubtful existence.

"It is a further object of the present invention to present the above information in a form and manner which will attract and hold the attention of students beginning the study of chemistry and will effectively assist in making clear the meaning of the symbols commonly used for the designation of chemical elements and compounds, as well as in clarifying the concept of valence."

Exclusive rights for manufacture and distribution of this "Chemical Formulator" have been assigned, by the inventor, to Cambosco Scientific Company, of 37 Antwerp Street, Boston, Mass. In lots of twelve or more, the Formulators are furnished at \$2.40 per dozen. The manufacturer will send a single, postpaid sample on receipt of thirty cents in stamps or coin.

HEREDITARY DIFFERENCES IN MAN

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In 1865 Gregor Johann Mendel announced the discovery of his now famous laws of heredity. His ample data consisted of pedigree records of garden peas obtained from hybridizing experiments carried on over a period of eight years. His results were clear-cut and decisive. They were fully presented and thoroughly analyzed by him. Two laws or principles were deduced. The first of these, which has come to be known as the *law of segregation*, states that hereditary differences among individuals depend upon differences in cellular units or "formative elements" (now known as genes); that these units are present in pairs in the cells of organisms derived from fertilized eggs; that the sperms and eggs (collectively known as gametes) produced by such organisms each receives a single member of each pair, so that if a given pair consists of unlike genes two sorts of gametes are produced in equal numbers; and that at fertilization the union of like sperms and eggs occurs with the same frequency as the union of unlike gametes.

To illustrate, if we let the symbol A stand for a particular gene and a stand for an alternative (allele) of A , then a mating of two hybrids with respect to this gene pair, with the resulting offspring, is represented as follows:

(Hybrids)	Aa	\times	Aa
(Gametes)	A	a	A a
(Offspring)	AA	Aa	Aa aa
(Ratio)	1	:	2 : 1

Mendel's second principle, the *law of independent assortment*, states that in the gametes the genes from the different pairs are combined with genes from every other pair in all possible combinations in accordance with the laws of chance; and that fertilization likewise brings about all possible combinations of sorts of gametes according to the laws of probability. For example, a mating between a doubly hybrid individual and a pure-bred individual, with the resulting offspring, is represented by the table on the following page.

Through an unusual combination of circumstances Mendel's discoveries bore no fruit for a period of thirty-five years. In

(Parents)	$AaBb$		\times	$aabb$	
(Gametes)	AB			ab	
	Ab				
	aB				
	ab				
(Offspring)	$AaBb$			$Aabb$	
(Ratio)	1		:	1	
			:	1	
			:	1	

1900, however, the appearance of three papers by independent investigators, each confirming the laws, set going a remarkable development in the study of heredity along the lines laid down by Mendel. As a result a great body of fact and principle has been built up into the complex and still vigorous and growing science of *genetics*.

In spite of the fact that during this modern period Mendel's principles have been shown to apply—as he predicted—to plants in general, as well as to animals and to man, we find many people, including some of those trained in science, showing great hesitancy in admitting the applicability of the laws to human beings. This reluctance is no doubt due in part to unfamiliarity with the recent literature of the subject, since much of the progress in the study of human heredity has taken place during the past ten or fifteen years.

As an illustration of the skepticism which seems no longer justifiable let us consider the following statement from one of our leading anthropologists:

"Unfortunately, the laws of heredity in man are not clearly known, and it is not yet possible without overstepping the bounds of sound, critical, scientific method to apply them to the study of the characteristic of a population. . . . Observation of various features of the body of man shows that the simple forms of Mendelian heredity are not often applicable. It is true that in a number of cases of pathological modifications, the validity of the simple Mendelian formulas has been established. Even in these cases the number of observations is not sufficient to determine whether we are dealing with exact Mendelian ratios or with approximations. Practically all other cases are still open to doubt."¹

An examination of the current journals published in this country and in Europe as well as recent books and monographs on human heredity (a few of which are listed at the end of this

¹ *Race, Language and Culture*, p. 34, by Franz Boas, The Macmillan Company, 1940.

paper) should convince the reader that literally hundreds of physical or physiological characteristics, accompanied in some cases by specific mental modifications, are now established as Mendelian beyond a reasonable doubt. In this connection it is well to emphasize a point that is often overlooked, namely, that Mendel's laws are statistical laws and that therefore they always involve the idea of probability. This means that exact ratios should seldom be realized. Close approximations are not only sufficient proof, but are actually to be expected more often than are exact ratios.

It is true that the great majority of the paired characteristics in man which have so far been successfully analyzed consist of a pathological trait vs. a normal one rather than two alternative normal traits. The explanation for this is not far to seek. According to present theories a gene is at least as complex an entity as a large protein molecule; whether it is a single molecule or a more complex unit cannot yet be stated. Mendelian variations apparently result from sudden changes in the structure of the gene. These changes, known as mutations, are brought about in some cases at least by forces outside the gene operating in a random manner. The directions in which a gene may be altered seem to be numerous, judging from the fact that many series of multiple alleles are known. Some of these series in the extensively investigated plants and animals contain a dozen or more alleles. A random change in a physiological factor in the development of a complex organism should in theory most often produce an injurious effect, just as a random change in a complex non-living machine is not likely to improve but to reduce the efficiency of the machine. Only rarely should a mutation result in an adaptive change or even in a change that is neutral in effect.

A living organism is the product of a long series of generations during which adaptive genes have slowly accumulated. In each generation selection has operated against the preservation of deleterious genes. The tendency to suffer from deleterious mutations seems to be the price that evolving organisms must pay for the possibility of enjoying useful ones.

In a species existing in large numbers and widely distributed in a variety of habitats it is usual to find great variability, with numerous varieties, local races, or subspecies. Some of the differences among the groups may be adaptive, fitting them to local environmental conditions; others may be differences of no

selective significance—differences which have arisen merely from isolation and chance preservation of neutral mutations. Among the mammals, man is our best illustration of a species with both types of variability. This paper is limited to a discussion of some of the non-adaptive or neutral hereditary characteristics in the human species.

NORMAL HEREDITARY DIFFERENCES IN MAN

For the purposes of the following discussion a normal or neutral trait may be defined as one which has not been shown to result in any disadvantage to its possessor in the struggle for existence, even though the trait may be rare in the population. Obviously, there is no hard and fast distinction between the two categories of traits, since a character which is normal under one set of conditions may be abnormal under a different set. For example, a fair skin might turn out to be pathological on an individual shipwrecked without clothing on a tropical island devoid of shade. In the accompanying list, Table I, some of the traits which occur in a minority of the population are *dominant*, i.e., they develop in the presence of even a single dose of the gene, in contrast to the *recessive*, which is able to develop only in the presence of a pair of identical genes. Many cases are known in which there is no dominance, the hybrid, with its pair of unlike genes, differing from both pure types.

TABLE I
Normal Mendelian Characters in Man

Dominant		Recessive	
White forelock	(FF)	Self color	(ff)
Non-red hair	(EE)	Red hair	(ee)
Woolly hair	(WW)	Non-woolly hair	(ww)
Brown iris-color	(CC)	Blue iris-color	(cc)
Taster	(TT)	Non-taster	(tt)
Blood group A	(I ^a I ^a)	Blood group O	(ii)
Blood group B	(I ^b I ^b)	Blood group O	(ii)
Blood type Rh +	(RhRh)	Blood type Rh -	(rrrh)
(Showing no dominance)			
Blood group A	Blood group AB (I ^a I ^b)	Blood group B	
Blood type M (MM)	Blood type MN (MN)	Blood type N (NN)	
Curly hair (CuCu)	Wavy hair (Cucu)	Straight hair (cucu)	

So far as the writer is aware none of the listed differences has been shown to have any adaptive significance. They are not pathological. It is possible, of course, that some of the genes may be found later to have an effect in addition to the one indicated; cases of the multiple effect of a single gene are numerous

in plants and animals and a few have been described in man.

The frequency of a particular character varies from population to population. A population may therefore be described by giving the frequencies of its traits or the estimated frequencies of the genes responsible for the traits. Brief descriptions of the characters listed in Table I, with data on the frequency of some of them will be given.

White forelock is characterized by a white spot in the skin and hair at the junction of the scalp and forehead in the midline. It resembles the white "star" above the eyes in horses and some other mammals. Although quite rare, most persons no doubt see one or more cases during their lifetime. No studies of the frequency of white forelock in the population seem to have been published. So far as known the sole effect of the gene is on the distribution of pigment. There is no evidence that the trait has any selective importance.

Red hair has a much higher frequency than white forelock; it is especially common among people of Scotch and Irish ancestry. It is inherited in the same manner as red hair in many other mammals, that is, as a simple recessive. It is a good example of a non-adaptive difference.

Woolly hair of the Caucasoid type is extremely rare, having been reported in only a few families, chiefly in Northern Europe and in the United States. Superficially it resembles the woolly hair of Negroes but is said to be distinguishable therefrom. It is inherited as a simple Mendelian dominant. The woolly hair of Negroes appears to depend upon several genes.

Wavy or curly hair is often mentioned as a characteristic of Caucasoids. It is also a trait of the aborigines of Australia and of some other groups. Straight coarse hair is characteristic of the Mongoloids. Neither curly nor straight is dominant since the hybrid from these two is intermediate or wavy.

There are numerous iris-colors in man, varying from dark brown through various shades of brown, green, gray, and blue to pink. Variations in the distribution of the pigment, producing spots, rings, and streaks also occur. Many of the details of the heredity of these differences remain to be worked out. It seems well established, however, that the clear blue eyes found in the blondes of Northern Europe differ from brown eyes of Caucasoids by a single gene, with brown dominant over blue.

In 1931 an American chemist, Dr. A. L. Fox, discovered a striking difference among people in their ability to taste the

substance phenyl-thio-carbamide ($C_7H_7N_2S$). From a study of pedigrees several geneticists promptly showed that the ability to taste this compound was inherited as a simple dominant. A number of racial groups have been tested and in all of these the non-tasters are in the minority, although the frequency varies remarkably from race to race. Data from the work of several investigators as summarized by Strandskov² show that about 30 per cent of white Americans are non-tasters as compared with about 23 per cent for Alabama Negroes, 6 to 13 per cent for American Indians, and about 7 per cent for Japanese and Chinese.

The four major blood groups, O, A, B, and AB, discovered in 1900-1902, depend upon the existence of three different forms of a particular gene, making a series of triple alleles. Every human being so far tested belongs to one of the four groups. The genetic formulas for those are as follows:

<i>Blood group</i>	<i>Genotype</i>
O	ii
A	$I^a I^a$ or $I^a i$
B	$I^b I^b$ or $I^b i$
AB	$I^a I^b$

Gene I^a as well as gene I^b is dominant over gene i , but neither of the first two is dominant over the other. Physiologically I^a causes the production of a specific agglutinin (A) in the red corpuscles; gene I^b induces the formation of a different agglutinin (B). Persons of group AB have both of these agglutinogens; those of group O have neither.

The frequency of the four groups has been studied in practically every racial and national group in the world through the efforts of many investigators. A recent summary of the data is given by Wiener. From the anthropological point of view the results are most interesting. All three genes are found to be present and widely distributed in all three major divisions of mankind, the Caucasoids, the Mongoloids, and the Negroids, as well as in most of the racial subdivisions. In the United States, tests of many thousands of persons indicate the frequency of the groups to be roughly as follows: O 45%, A 38%, B 12%, AB 5%. These proportions are fairly typical of the peoples of Western Europe. As one travels eastward through Europe and Asia and southward into Africa and India there appears a more or less

² Strandskov, H. H. (1941), "The Distribution of Human Genes." *Sci. Monthly*, 52: 3, 203-215.

gradual rise in the percentage of group B. In Europe and Japan this rise is largely at the expense of group O; among African Negroes it is at the expense of group A; and on the continent of Asia it is at the expense of both O and A. There are high spots in the frequency of B in the centers of Asia and Africa, with a falling off in all directions.

Among North American Negroes the group frequencies resemble closely those of the natives of the Congo region of Africa, as might have been expected from the known origin of the Negroes in this country. The figures for Negroes are approximately as follows: O 47%, A 28%, B 20%, AB 5%.

The most striking variations from the distributions in the larger populations are found among certain small and isolated populations, as illustrated in the following:

	O	A	B	AB
		Percentage		
Southern Australians	44	56	0	0
Indians (Peru)	100	0	0	0
Bush Negroes (Dutch Guiana)	83	0	17	0

Knowing the frequencies of the blood groups in a population it is possible, assuming random matings with respect to blood groups, to calculate the frequencies of the three genes, I^a , I^b , and i . The extensive list of gene frequencies given by Wiener shows that in all but a few populations the recessive gene i is more frequent than the other two combined.

Several attempts have been made to find some correlation between the blood groups and various other characters, including susceptibility to specific infections and other diseases, but without success. There is no critical evidence that any of the groups has any selective importance. They seem merely illustrations of non-adaptive differences that have arisen through mutation and chance preservation.

Although the major blood groups are the best known examples of chemical differences among individuals, many other specific differences have been found. Very recently Landsteiner and Wiener³ reported the discovery of an agglutinin in human blood which they call the *Rh* factor because the same substance is present in the blood of the rhesus monkey. About 85% of whites tested in New York City possessed this agglutinin; the remaining 15% lacked it. Studies of families carried out by these

³ Landsteiner, K. and A. S. Wiener. (1941), "On the *Rh* Agglutinin." *Journ. Exp. Med.*, 74: 4, 309-320.

investigators indicate that a dominant gene is responsible for the presence of the substance.

In 1927 Landsteiner and Levine discovered two agglutinogens known as M and N, each due to the presence of a separate gene, *M* and *N*, respectively. Neither gene is dominant; individuals with both (*MN*) develop both agglutinogens. All human bloods so far examined have either the one agglutininogen or the other, or both. The M-N series would therefore be like the A-B series genetically provided the gene *i* in the latter series did not exist.

Just as in the case of the major blood groups, there is considerable variation in the proportions of the three types, M, N, and MN among the populations. For example, in many Europeans and in American whites, Japanese, and American Negroes the proportions are about the same, with type M somewhat more frequent than type N; among Finns, Swedes, Chinese, and Hindus there is a greater excess of M; and in American Indians a still greater excess of M over N. Eskimos of East Greenland are reported to show the greatest excess of all with type M present in about 84% and type N in less than 1%. The Ainu of Northern Japan, a people of largely Caucasoid stock, are exceptional in showing an excess of type N (about 18% M, 32% N, and 50% MN). No correlation has been found between the M-N series and the A-B series. The blood types are not known to have any adaptive significance. Their distribution among the races suggests that we are dealing with a non-adaptive or neutral difference.

So far, in the present discussion no mention has been made of independent assortment as applied to man. It is now known that only those genes show independent assortment that are present in different chromosomes. Genes that are in the same chromosome exhibit the phenomenon known as linkage, i.e., they stay together more often than they separate in their distribution to the gametes. Inasmuch as there are 24 pairs of chromosomes in the human species and human genes are presumably apportioned more or less uniformly to the chromosomes according to the relative size of the latter, it is probable that any two Mendelian traits chosen at random will show independent assortment. If each of the 24 chromosomes were to contain the same number of genes as every other, only once in 24 times would two genes selected at random be found in the same chromosome. Since there is a gradation in size of the human chromosomes, with the longest several times the length of the shortest, this

chance must be considerably greater than one in 24: the chance of two genes chosen at random being located on any one of several chromosomes varies directly with the square of the lengths of the chromosomes.

In the study of human heredity it is obviously impracticable to apply the experimental method which has proved so fruitful in the investigation of heredity in plants and animals. Because we are limited to the observation of human families as we find them progress has been slow in the attempt to trace simultaneously two or more traits for the purpose of discovering whether they assort independently. No certain cases of linkage between either the blood types or the blood groups and other characters have been found, although a dozen or so traits have been investigated with this question in mind. The blood groups of the A-B series are not linked with the blood types of the M-N series. It is merely a question of time, however, until cases of linkage (other than cases of sex-linkage, several of which are known) are discovered. Only within the past year has the first case of linkage been reported in the guinea pig (a mammal with a large number of chromosomes) although the guinea pig has been bred extensively in genetics laboratories for many years. All things considered we have no reason for thinking that man differs basically from the other mammals in his mechanism of heredity. Man is unique in his assortment of genes.

Many of our racial differences such as skin-, hair-, and eye-color, hair form, facial features, skull shape, size, and body conformation have not been fully analyzed in Mendelian terms, perhaps because in most cases they depend upon more than one gene difference. As far as we can see, few of these differences are of any adaptive significance.

The discovery and cataloging of all innate factors or genes which play a part in producing differences among men and races and the establishment of these in linkage groups is one of the goals of the human geneticist. The realization of this goal lies in the distant future. However, as knowledge accumulates, its continuous wise application is bound to have great value in promoting the happiness and progress of mankind the world over. The only sure cure for distorted and erroneous ideas of racial and individual differences, which are widespread in the world today, is more facts and extensive teaching of the facts.

One who studies intensively the human species cannot fail to be impressed by the enormous variability within each major

division and race. Due to this great variability and to the tendency for the same genes to appear in all racial stocks the differences among races as such must in large part be a matter of differences in gene frequencies. In characters that really matter the striking thing is not the differences among the races but the number of respects in which all races are alike.

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A PRE-INDUCTION TEXTBOOK

A textbook written to meet the requirements of the pre-induction course in Fundamentals of Machines as outlined by the War Department and the U. S. Commissioner of Education is being published by D. Van Nostrand Company. The authors are Elmer E. Burns, Frank L. Verwiebe and Herbert C. Hazel.

VARIATION AMONG GENERAL SCIENCE TEXTBOOKS*

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Analyses and comparisons of general science textbooks have been made by more than a few investigators, with findings that in general show agreement with each other.

Downing¹ summarized in 1928 the work of several graduate students at the University of Chicago. The page space devoted to twenty major-topics in twelve general science textbooks was measured by Overn in 1921, and a similar analysis was made of thirteen additional books in 1927 by Iler. The conclusion was reached that there was no consensus of opinion as to what should be included in general science textbooks, and that the later books showed no increase in the unanimity of opinion.

Wolford,² in a later study, likewise found little apparent agreement among writers as to what should be included in a textbook of general science.

Some contemporary educators have expressed the opinion that recent textbooks are developing more uniformity in type and distribution of content while others are certain that the great variation still exists. It was thought desirable, therefore, to make an analysis of recent editions of general science textbooks, in order to determine what, if any, changes have taken place.

Nine textbooks were selected for study. They are the following:

1. Franklin B. Carroll, Frank A. Rexford, and Henry F. Weed: *Understanding the Universe*. John C. Winston Co., 1931.
2. Ira C. Davis and Richard W. Sharpe: *Science*. F. C. Holt and Company, 1936.
3. Benjamin C. Gruenberg and Samuel P. Unzicker: *Science in Our Lives*. World Book Co., 1938.
4. John C. Hessler and Henry C. Shoudy: *Understanding Our Environment*. Benj. Sanborn and Co., 1939.
5. George W. Hunter and Walter G. Whitman: *Problems in General Science*. American Book Co., 1939.

* From dissertation for degree of Doctor of Education entitled "An Analysis of the Science Content of the New York Times and of Selected General Science Textbooks." Temple University, Philadelphia, 1942.

¹ Downing, Elliot R.: "An Analysis of Text-Books in General Science." *General Science Quarterly*, May, 1928, Vol. XII, pp. 509-516. Summary of Master's Theses (University of Chicago) by O. E. Overn, Ernest Iler, and Ailsie M. Heinemann.

² Wolford, Feaster: "Methods of Determining Types of Content for a Course of Study for Eighth-Grade Science in the High Schools of the Southern Appalachian Region." Unpublished dissertation for the degree of Doctor of Philosophy, Cornell University, 1935.

6. Charles H. Lake, Henry P. Harley and Louis E. Welton: *Exploring the World of Science*. Silver Burdett & Co., 1939.
7. E. J. Van Buskirk, E. L. Smith, and W. F. Nourse: *The Science of Everyday Life*. Houghton Mifflin Company, 1936.
8. Ralph K. Watkins and Ralph C. Bedell: *General Science for To-Day*. Macmillan Company, 1936.
9. Hanor A. Webb and Robert O. Beauchamp: *Science by Observation and Experiment*. D. Appleton-Century Co., 1935.

The material in the textbooks was classified into fifteen topics as shown in Table I. The textbook space was measured to the nearest one-quarter page, with the omission of questions, experiments, and summaries appearing at the end of chapters. The page distributions among the fifteen topics in the textbooks were converted into per cents as shown in the table.

TABLE I
Per Cent of Total Pages Devoted to Each Topic by Nine
General Science Textbooks

TOPIC	Cartoll	Davis	Gruenberg	Hessler	Hunter	Lake	Van Buskirk	Watkins	Webb
1. Health and Medicine	12.5	11.7	11.8	16.9	17.1	12.9	16.2	15.3	14.4
2. Communication and Transportation	6.6	6.5	5.5	3.2	10.5	4.9	14.8	6.2	18.7
3. Animal Life	3.9	1.1	2.6	7.7	3.6	5.7	2.2	6.1	3.3
4. Man and Behavior	3.5	11.7	15.5	1.7	6.5	2.1	5.0	10.0	5.3
5. Gardening and Agriculture	6.1	2.9	0.2	2.4	2.7	4.4	2.9	2.0	3.4
6. Earth Science	8.3	4.2	8.8	6.2	4.3	5.1	3.8	7.5	8.0
7. Weather and Forecasting	3.2	4.6	4.4	6.4	4.9	6.1	4.6	3.2	3.2
8. Applied Chemistry	5.9	6.4	5.2	9.3	11.9	7.7	14.1	6.2	9.1
9. Atomic Investigation, etc.	0.5	1.4	1.8	0.3	0.5	0.6	0.4	1.7	0.5
10. Astronomy	6.0	2.9	4.3	6.1	6.6	6.9	3.3	5.1	10.8
11. Forms of Energy, Applications	18.8	19.6	20.6	19.0	15.1	19.5	15.0	16.7	12.8
12. Conservation	1.6	1.3	0.7	3.7	1.7	0.4	1.0	3.8	—
13. Plant Life	8.4	6.3	3.8	7.1	3.5	6.4	4.4	2.9	3.6
14. Principles of Chemistry	6.7	5.7	4.7	3.9	5.0	6.9	4.8	6.9	2.1
15. Mechanics	7.9	13.7	10.1	6.2	6.0	10.4	7.6	6.4	4.9

An examination of Table I shows that a good deal of variation exists among the textbooks with respect to the space allotments for some of the topics. All the authors agreed in devoting appreciable space to Topic 1, and to Topic 11 which includes light, heat, sound, and electricity, while Topics 3, 4, 5, and 12 were treated very fully in some texts and almost completely ignored in others.

It might perhaps be argued that there is no special virtue in having uniformity in science textbooks. It was noted, however, that no authors stated any aim in meeting the particular needs of any specific group of students or local conditions. In the absence of any apparent influence of special conditions, the divergence between the textbooks would seem to be explained

largely by the differing opinions of the various authors as to what should be the apportionment of the various topics in textbooks, and by the type of science background possessed by those authors.

In the monumental *Thirty-First Yearbook* of the National Society for the Study of Education, both Curtis³ and Pieper⁴ deprecate the fact that the general science books extant at the time of their writing in 1932 generally devoted a greater proportion of space to the physical sciences than they did to the biological sciences.

In order to determine the condition in the more recent textbooks used in this study, the approximate per cents of space devoted to biological science were found by totalling the per cents devoted by the textbooks to the topics of Health and Medicine, Animal Life, Man and Behavior, Gardening and Agriculture, Conservation, and Plant Life. The per cents devoted to the remaining nine topics were combined under physical science. The results are shown in Table II.

TABLE II
Per Cent of Space Devoted to Biological Science and Physical Science by General Science Textbooks

Textbook	Percentages	
	Biological Science	Physical Science
1. Carroll	36.0	63.7
2. Davis	35.0	65.0
3. Gruenberg	34.6	65.4
4. Hessler	39.5	60.6
5. Hunter	40.7	59.2
6. Lake	31.9	68.1
7. Van Buskirk	31.7	68.4
8. Watkins	40.1	59.9
9. Webb	30.0	70.1

The space distribution varied from 30.0 per cent for biological science and 70.1 per cent for physical science in Webb, to 40.7 per cent for biological science and 59.2 per cent for physical science in Hunter. The average proportion of the nine books was 35.5 per cent for biological science and 64.5 per cent for physical science.

This would seem to indicate that the general science textbooks are unfavorably balanced at the expense of biological science. Considering, however, that topics in physical science

³ Curtis, Francis D.: "Curricular Developments in the Teaching of Science." Chapter IX, p. 122, "The Thirty-First Yearbook of the National Society for the Study of Education."

⁴ Pieper, Charles J.: "Science in the Seventh, Eighth, and Ninth Grades." Chapter X, p. 207, "The Thirty-First Yearbook of the National Society for the Study of Education."

probably offer greater difficulties for students, this unbalance may not be as unfavorable as it at first glance seems.

The findings of this analysis appear to coincide with earlier studies in that:

1. Secondary school general science textbooks show a fairly large variation among themselves with respect to amount of space devoted to various topics in science.
2. Secondary school general science textbooks generally devote a greater proportion of space to the physical sciences than to the biological sciences.

TEACHING *MUST* BE WAR WORK

In a special bulletin, Selective Service Director Hershey notified all draft boards that "educational services are essential to the war effort."

Considered essential are educational services in public and private industrial schools, elementary, secondary and preparatory schools, junior colleges, colleges and universities, educational and scientific research agencies, and those producing technical and vocational training films.

Director Hershey told local selective service boards that in considering registrants engaged in educational services, they must take into account the occupation in which the men are engaged. The critical occupations in each of the educational services were named as follows:

ELEMENTARY, SECONDARY AND PREPARATORY SCHOOLS: Superintendents of elementary, secondary and preparatory school systems; and teachers who are engaged in full-time instruction in one or more of the following subjects: Aeronautics, biology, chemistry, mathematics, physics, radio.

JUNIOR COLLEGES, COLLEGES, UNIVERSITIES AND PROFESSIONAL SCHOOLS, EDUCATIONAL AND SCIENTIFIC RESEARCH AGENCIES: Presidents, deans, and registrars in junior colleges, colleges, universities and professional schools; and professors and instructors engaged in full-time instruction and research in one or more of the following subjects: agricultural sciences; architecture, naval; astronomy; bacteriology; biology; chemistry; dentistry; engineering sciences; geology; industrial management; mathematics; medicine and surgery; metallurgy; meteorology; navigation, aerial and marine; oceanography; pharmacy; physics; physiology; veterinary sciences.

PUBLIC AND PRIVATE INDUSTRIAL VOCATIONAL TRAINING: Superintendents of public and private industrial vocational training; and teachers who are engaged in full-time instruction in one or more of the following subjects designated to prepared students for war activities: trade, vocational and agricultural subjects (such as machine shop practice, aircraft, sheetmetal work, and similar subjects) and in vocational rehabilitation.

PRODUCTION OF TECHNICAL AND VOCATIONAL TRAINING FILMS: Persons engaged full-time and exclusively in the production of technical and vocational training films for the Army, Navy, and war production industries.

CHEMURGY A FACTOR IN NATIONAL DEFENSE

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Some six years ago there assembled in Dearborn, Michigan, a group of agriculturalists, scientists, and industrialists. The conference of these men was considered of so little importance to the general public that not even the newspapers carried a story of the proceedings. This was of slight concern to these men, however, for they were not seeking publicity. They were assembled for the purpose of finding some way in which the farmers of this great land could be given an opportunity to relieve their plight by allying themselves with industry. This movement was given the name chemurgy and defined as "putting chemistry and related sciences to work in industry for the farmer and indirectly for society in general."¹

Chemurgy is an excellent example of correlated science. Chemists working in research laboratories find that a desirable plastic can be produced from the protein of the soy bean. The biologists then set to work to produce a variety of soy bean with a high content of the protein used in the plastic. The problem of finding new uses for our surpluses is largely the task of the chemists, while developing new varieties of crops and growing formerly imported crops in this country are problems to be solved by biologists.

Chemurgy's problem is then to enlarge the opportunity for our six million farmers to produce and it seeks to accomplish this end by permitting them to produce every possible agricultural item we consume and to find uses for their agricultural wastes.

This brings up the widely discussed question of self-sufficiency in connection with our National Defense Program. The desire for national self-sufficiency has been the cause of an economic turmoil in which the entire world is now involved.

In 1931, Japan walked into Manchukuo for the purpose of seizing food supplies. The temptation for a higher degree of self-containment, however, proved too great and the seizure of food supplies was followed by a seizure of mineral supplies. The vanquished nation of World War I, under the direction of one man has been able to build up such a perfected degree of self-sufficiency that it now seems necessary for every country in the world

¹ *The Farm Chemurgic Journal*, Sept., 1937, preface.

to do the same. The potential power of a nation is now measurable by the nation's self-containment.

For a nation to become self-sufficient, two obstacles must be overcome. First, it must be able to utilize its surpluses created by a decline in imports and by "over-production." Secondly, it must supply itself with valued produce imported from other countries. This is where America is depending upon chemurgy. Chemurgy can make us self-sufficient or nearly so in raw materials.

Somewhere in the United States can be found almost every combination of soil, temperature, altitude, and humidity. This one fact is a foundation for much of the hope for chemurgy's power of making us independent of imports. The soy bean is a good example of what can be done when our resources are allied. Until only a few years ago, we were entirely dependent upon the Orient for our supply of soy bean meal and oil. A research program was instituted and work begun on the problem of growing soy beans in the United States. It was found that a good variety, adaptable to industrial uses, could be grown with very little difficulty within our own borders. Now soy bean oil is the only drying oil produced domestically in quantities sufficient to fill our requirements for defense.²

The success of the production of tung oil has been less rapid than that of the soy. This is probably due to the different natures of the two plants. Whereas the soy bean plant will grow in almost any climate with little cultivation, the tung tree requires a very warm temperature and much care in cultivation. The period required for maturity is another factor which favors the "over-night" rise to fame of the soy. Notwithstanding these factors, tung trees are being grown with some success in our Southern states.

An entirely new field for chemurgy lies in the castor bean from which can be extracted an excellent drying oil. Castor oil is similar to tung oil, but above this it has its own merits. In the year ending June 30, 1940, our castor bean imports valued \$5,132,000.³ At the same time they were maturing in this country. It is a known fact that they can be grown within our borders. However, there have been no appropriations to promote research to determine the most favorable varieties and where

² Trigg, Ernest T. "Drying Oils in Defense and Beyond." *National Chemurgic Council*, March 27, 1941, p. 3.

³ Wheeler, McMillen, "Chemurgy and War." *National Chemurgic Council*, Sept. 16, 1940, p. 3.

they can best be grown. With the impetus that defense is giving to drying oil, research, it is not false optimism to expect the history of the castor bean in this country to be somewhat of a repetition of that of the soy bean.

With the increased demand for paint in defense needs, and with the increased domestic production of their most essential constituent, drying oils, chemurgy will have launched another battle-ship to take its place in the first line of defense.

Certain materials, such as rubber and tin, for obvious reasons cannot be produced in this country. The solution to this problem lies in the development of substitutes. Here chemurgy's accomplishments are not so numerous as in the field of drying oils and the future is not so bright. True, synthetic rubbers are now being produced on a commercial basis, but they are not chemurgic synthetics. Later, however, it may be found that materials used as starting materials in synthetic rubber can be obtained from farm products.

It has long been known that alloys could be substituted for tin in many instances, but more recently cellulose derivatives have been developed. Germany has been preserving food in cellulose containers since 1938 and if, after more research has been carried on, these derivatives have proven adaptable to our needs there will be no shortage of raw materials. The farmers of our country will be able to supply all the cellulose needed.

All Americans at some time or other have realized the comparative smallness of our imports considered relative to our exports. What is happening to our agricultural exports now in this international crisis and what is chemurgy's part? Our exports declines nineteen per cent from September 30, 1939 to July 1, 1940⁴ and since that time the decline has continued. This decline can be traced to two causes: first, our national policy; and second the blockade. Under the Lend-Lease Act all materials bought must be paid for in cash. With a limited purchasing power, European countries are naturally investing it in munitions and other materials necessary to carry on the war. At the same time, to fill their food requirements, they are expanding their production of agricultural products wherever possible. The result is that while we are faced with these problems for which there seems to be no immediate solution, our farms are producing more and we are faced with a surplus. Chemurgy has partially

⁴ Whitney, N. R. "Some Possible Effects of the War on American Agriculture." *National Chemurgic Council*, Sept. 16, 1940, p. 2.

solved this situation: First, by developing new industrial uses for these agricultural surpluses; and secondly, by attempting to interest the farmer in planting some of the acres formerly used in growing crops now considered surplus with new crops of chemurgic importance. It must not be interpreted that until recently there have been no industrial uses of agricultural surpluses. That is not true. For years, there have been several minor uses of farm products in industry. The present chemurgic movement seeks to expand these old uses and develop new ones.

Corn is an excellent example of this aim of chemurgy. For some twenty years companies such as the Commercial Solvents Corporation of Terre Haute, Indiana and of Peoria, Illinois, have been utilizing excess corn in the lacquer industry.⁵ Fermentation of corn by *Clostridium acetobutylicum* results in butyl alcohol, while the conventional fermentation results in ethyl alcohol. These alcohols are the most important solvents in the lacquer industry—butyl alcohol being an excellent solvent for nitrocellulose lacquers made from cotton, while ethyl alcohol is second only to water as an industrial solvent. Though actually only a little more than two per cent of the farm crop finds chemurgic use, the above suggests some of the possibilities chemurgy may find for this particular crop. From corn can be obtained rather easily and inexpensively such materials as acetone, wood alcohol, carbon dioxide, and a considerable quantity of alpha-cellulose as well as the two solvents already mentioned. Just to mention one, methanol finds such wide spread industrial uses as a solvent for lacquers and plastics, as well as being a raw material for the formaldehyde and urea-formaldehyde type of plastic. Corn may become the source of raw materials for chemical industries in the future.

Regardless of the conflicting opinions as to the outcome of the present war, everyone agrees on one thing—that is, that the economic reconstruction necessary at its close will be a problem greater than has ever before been met in history. Just as the tactics of this war differ from World War I, so the economic reconstruction will differ. America will be faced with a loss of markets all over the world and at the same time there will remain the threat to foreign raw materials and food stuffs. Chemurgy's part in post-war economy will be much the same as it is in our present defense program: More research to find more and wider uses for

⁵ Furnas, C. C. "The Farm Problem—Chemurgy to the Rescue." *The American Scholar*, Winter, 1940-41, pp. 27-28.

agricultural products in industry. In the production of our farms will be the assurance of an abundance of raw materials as well as an abundance of food stuffs for America.

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TABLES TURNED

Faculty members at Indiana State Teachers College know what their students think about them. Students rate their professors each year on 10 points: affability, enthusiasm, industry, judgment, earnestness, scholarship, English, teaching procedure, stimulating power and general worth. The student rating plan is a definite part of the Institution's policy to improve the faculty.

NEGRO EDUCATION

Authorities of Atlanta University are to be congratulated for their far-seeing vision in placing at the disposal of the citizens of Atlanta, The People's College, a new innovation in education in this community, whereby citizens in all walks of life, irrespective to previous educational background, are to be given the opportunity to participate.

A great number of courses, including baking duties, statistical arrangements, interviewing callers, telephone technique, handling reference books, filing, billing and invoicing, and development of desirable physical and personality traits, are to be offered, together with many other useful subjects which should be of inestimable value to those whose educational preparation, for one reason or another, is not what they wish it to be. . . . There is to be no charge for tuition, it is announced, but there is to be a small registration fee of fifty cents to be charged. . . .

We can think of at least 50 Negro citizens, who have made history for their race, including the late Booker T. Washington, who would have considered The People's College their golden opportunity for an education, which they were denied.

Atlanta Daily World

THE NEWTONIAN WORLD-MACHINE

300 YEARS OF ISAAC NEWTON*

RALPH MANSFIELD

Chicago Teachers College, Chicago, Illinois

Nature and Nature's laws lay hid in night:
God said, "*Let Newton be!*" and all was Light.¹

The influence of science colors the entire mental outlook of modern civilized man on the world about him. Perhaps one of the most telling evidences of this is his growing freedom from superstition. Freedom from superstition is the result of the conviction that the world is not governed by caprice, but that it is a world of order and can be understood by man if he will only try hard enough and be clever enough. This conviction that the world is understandable is, doubtless, the most important single gift of science to civilization. The widespread acceptance of this view can be dated back to the discovery by Newton of the universal sway of the law of gravitation; and for this reason Newton may be justly regarded as the most important single contributor to modern life.

There were very few problems that Newton could not answer; still smaller were the number his endeavors did not lead him to attempt to answer. He made water clocks and sundials, and models of engines and instruments; like Galileo he was fascinated by telescopes and, from observing their defects, he discovered laws of optics. He invented new ways of attacking mathematical problems, revolutionizing the whole science of mathematics by his discovery of the fluxions, or differential calculus, and the binomial theorem. From early childhood he never ceased to observe, to think, and to invent.

What did all this activity contribute to the modern man's problem of his attitude to the universe? Can we understand our life or imagine our universe without knowing what Newton gave the human imagination? It is almost impossible to have a useful opinion about life, or the universe, without first getting a glimpse of this gift. And yet all most of us know or care about it is that Newton "saw an apple fall and discovered gravitation," a fact which means very little and certainly does not help in our concepts of a better life.

Newton appeared at a very fruitful period in the development

* In commemoration of the tercentenary of Newton's birth, Dec. 25, 1942.

of the modern mind. The stage was set for a genius and Newton appeared on the scene. Copernicus, Kepler, Tycho Brahe, Descartes, Galileo had all performed. The time was ripe for a fitting climax. That Newton realized the importance of his predecessors is apparent from his statement, "If I have seen farther (than other men), it is because I have stood on the shoulders of giants." It is perfectly true that Newton's greatest achievement was to collect all the discovery and reasoning of the past and to weld it into a complete and perfect whole, complete and perfect in the sense that the Aristotelian picture of the universe was perfect. So far, various pictures of the universe had passed in review—"band-box universes." The summary of these revolutions in knowledge serves to show that the old answers to how the universe behaves as it does had been found to be wrong. A new answer to the *how* had been given by Copernicus and Kepler. Nobody had as yet tackled the *why*.

The intelligent man of the Middle Ages reasoned like this:² "How does the universe move? In circles, in spheres, by uniform speeds. How do I know this? Because such things are perfect and are needed to manifest God." In short, the *why*, God's nature, is taken as known, and the *how* is deduced from it. "God is perfect; therefore his creation is perfect and moves according to the standards of perfection; and this is how I know that the heavenly spheres move in circles round the earth." Then came the appalling discovery that the *how* was entirely wrong and that therefore the *why* was also wrong. The people who made this discovery said, "I will tell you how the universe behaves, but apart from my answer showing that the old answer to the *why* must be wrong, I shall have to leave the *why* entirely alone." It was thus far that the giants upon whose shoulders Newton stood had gone; Newton answered the *why*.

* * *

Newton observes in the preface to his *Principia* that "all the difficulty of philosophy seems to consist in this—from the phenomena of motions to investigate the forces of nature, and then from these forces to demonstrate the other phenomena." This statement is highly interesting in that it reveals the precise field to which Newton confined his work. It is the phenomena of motions that is to be the object of his study, and that study is to proceed by the discovery of forces, from which in turn demonstrations are to be drawn, applying to, and confirmed by, other motions.

Now this was a period of mathematical activity. The scientific advances of the time are well epitomized in the spirit of the Royal Society: "for the promoting of the Physico-Mathematical Experimental Learning." Descartes' development of the analytic geometry gave added impetus to this mathematical movement. Attempts were being made on all sides to reduce learning to mathematical terms. *Apriorism* spread rapidly through the schools of Europe. But for Newton there was no *a priori* certainty, such as Kepler, Galileo, and pre-eminently Descartes believed in, that the world is through and through mathematical, still less that its secrets can be fully unlocked by the mathematical methods already perfected. The world is what it is; so far as exact mathematical laws can be discovered in it, well and good; so far as not, we must seek to expand our mathematics or resign ourselves to some other less certain method. Newton expresses this thought in the preface to the *Principia*, "I wish we could derive the rest of the phenomena of nature by the same kind of reasoning from mechanical principles . . . but I hope the principles here laid down will afford some light to that or some truer method of philosophy."

The foundation of Newton's mathematical physics was free from any hypothesis assuming first or final causes. In fact, he even went so far in his attempt to free his physics from any metaphysical implications as to lay down the dictum: "*Hypotheses non fingo*." He did that, however, after a bitter polemic against him by the Cartesians—Hooke, Huygens, Lucas, Cassegrain, Pardies, and others. They all opposed Newton's use of hypothesis.

In Newton's physics and optics we can find two types of hypothesis. The first, which is simple, easy to use, and natural, is the hypothesis that forms the foundation of the atomic theory, the theory of undulation and emanation. This type of hypothesis is based as nearly as possible on the totality of observations after the analysis of observed facts of nature have been completed. In a well-developed science this kind of hypothesis becomes fact or disappears. The second is a complex hypothesis, which is made in order to complete a system. This type of hypothesis may be contradicted by the fact which it claims to represent, as in the case of Newton's early theory of light. Newton believed that hypothesis should be used in order to make new discoveries. According to either definition, then, hypothesis is made after certain facts have been analyzed and, by the use

of this hypothesis, a set of deductions are made and verified fully or partially.

These hypotheses must be, Newton thought, (1) clearly expressed; (2) they should follow experience, and never come before; (3) they must be suggested by the facts of the experience; (4) they must be formal; (5) they must not contradict the three rules laid down for all mathematical physics: (a) that we must not admit more causes than are true and are needed to explain the facts, (b) that we must ascribe equal causes to equal effects, (c) and that the qualities of bodies which cannot be lessened or reinforced, and which are found to be true of bodies that we have actually experienced, are true of all bodies. . . . In the last point Newton unconsciously assumed an important law of induction, a law which is really a speculative hypothesis.

Another assumption (6) which Newton made unconsciously, and which really is a dogmatic hypothesis, is in his use of mathematical concepts of relationship between phenomena—his assumption that the nature of physical facts corresponds step by step with the deductions employed in mathematical correlation of propositions. Even though we should begin our mathematical chain of deductions with general propositions which were the result of our observations of nature, and if also the resultant propositions were verifiable, nevertheless, the intermediate steps employed in our calculations may or may not have any correlations whatsoever with the world of physical phenomena. Newton, however, employing mathematics as a method of procedure, presupposed this general hypothesis that each step in a mathematical demonstration is true of the physical world.

Finally, (7) a good hypothesis for Newton does not attempt to answer the *why* but the *how* of facts, the *form* and not the *essence* of nature. The reason for this position on Newton's part was a traditional belief in a providential non-mechanical order, which was for him the final explanation of the universe. Such an *essence* would never be supplied, Newton thought, by science or natural philosophy in its development at his time, if ever. Newton believed that it may be hoped for when all of scientific knowledge is completed, as the final step, but probably it is the business of revealed theology to answer the *why* and the *essence* of things. In fact, it does not matter what kind of hypothesis we may develop, providing the different types give

rise to the same mathematical equation or law; though the *interpretation* of the equation will vary with the different hypotheses, the mathematical form will always be the same. Therefore, the nature of hypothesis is really similar to the nature of definition.

For Newton, then, science was composed of laws stating the mathematical behavior of nature solely—laws clearly deducible from the phenomena—everything further is to be swept out of science, which thus becomes a body of absolutely certain truth about the doings of the physical world. By his intimate union of the experimental and mathematical methods, Newton believed himself to have indissolubly allied the ideal of the exactitude of the one with the constant empirical reference of the other. For Newton, however, mathematics must be continually modelled on experience; and wherever he permitted himself lengthy deductions from principles he zealously insisted on the purely abstract character of the results till they became physically verified. This fact is well brought out in his discovery of universal gravitation.

Newton was not the first person to conceive of gravity, but by his careful analysis of the various factors involved he was able to demonstrate that one law could explain the action of every body in the universe, that law being built upon the work of Kepler and Galileo.

As early as 1665, at the age of twenty-three, Newton had somehow got hold of the notion of centrifugal force. It was six years before Huygens discovered and published the laws of centrifugal force, but in some quiet way of his own Newton knew about it and applied the idea to the motion of the planets. We can almost follow the course of his thought, so well described by Lodge,³ as he brooded and meditated on the great problem which had taxed so many previous thinkers:—what makes the planets move round the sun? Kepler had discovered how they moved. But why did they so move? What urged them?

Kepler, with his marvellous industry, had wrested from Tycho's observations the secret of their orbits. (1) They moved in ellipses with the sun in one focus. (2) Their rate of description of area, not their speed, was uniform and proportional to time. (3) The cubes of their distances were proportional to the squares of their times of revolution about the sun. But all this was only the first step. What made the planets move in this particular way? Descartes' vortices was an attempt—a poor and imperfect

attempt—at an explanation, but it did not satisfy Newton. It proceeded on a wrong tack, and Kepler had proceeded on a wrong tack in imagining spokes or rays sticking out from the sun and driving the planets round. For, these theories are based on a wrong idea:—the idea that some force is necessary to maintain a body in motion. But this was contrary to the laws of motion as discovered by Galileo:

1. If no force acts on a body in motion, it continues to move uniformly in a straight line.
2. If force acts on a body, it produces a change of motion proportional to the force and in the same direction.
3. When one body exerts force on another, that other reacts with equal force upon the one.

The first law is the simplest. The old idea had been that some force was needed to maintain motion. On the contrary, the first law asserts, some force is needed to destroy it. Leave a body alone, free from all friction or other retarding forces, and it will go on forever. The planetary motion through empty space therefore wants no keeping up. It is not the motion that demands a force to maintain it. It is the curvature of the path that needs a force to produce it continually. The second law asserts that when a force acts, the motion changes, either in speed or in direction, or both, at a rate proportional to the magnitude of the force, and in the same direction as that in which the force acts. Now since it is solely in direction that planetary motion alters, only a deflecting force is needed. A force acting at right angles to the direction of motion. Considering the motion as circular, a force along the radius—a radial or centripetal force—must be acting continually. The third law asserts that this centripetal force is equal to the centrifugal force—the outward force of the planet.

Thus then it became clear to Newton that the whole solar system depended on a central force emanating from the sun, and varying inversely with the square of the distance from it. For by that hypothesis all the laws of Kepler concerning these motions were completely accounted for; and, in fact, the laws necessitated the hypothesis and established it as a theory. Grant this hypothetical attracting force pulling the planets toward the sun, pulling the moon toward the earth, and the whole mechanism of the solar system is beautifully explained. It took man years to reach the point where he could comprehend the importance and need for such a law. It took Newton years of

labor to round his law into shape and publish it, thanks to the prodding of Halley. The final enunciation of the law was beautifully simple and concise: *every particle of matter in the universe attracts every other particle with a force directly proportional to the product of the masses and inversely proportional to the square of the distance between them.*

Now, to Newton, as well as to many of the natural philosophers of the time, the nature of gravity was unknown and what seemed especially puzzling was that action should take place at a distance, as it apparently did in the case of the gravitational effect of the sun upon the planets. Descartes had overcome the difficulty of action at a distance by his formulation of the theory of vortices. But Descartes' vortices were too viscous and offered too much resistance to the free motion of the planets in their orbits. So Newton set about to find something to fill all space and transmit all motion without hindering the motion of the planets. We cannot go into the details of Newton's work along this direction, but we can summarize it from the viewpoint of one of his critics.⁴

Newton conceived his mathematical expression of gravity not as a real explanation of the causes of gravity, but rather as an empirical law; as an algebraically expressed and experimentally verified fact of nature. Newton knew that the science of physics did not demand any further explanation. Nevertheless, he does suggest directly in his questions to the *Opticks* and in a letter to Boyle a possible mechanical explanation of the cause of gravitation, by the assumption of an ether hypothesis. On the other hand, Newton suggests indirectly and directly throughout his whole works another possible explanation which would contain the causes of gravity—an explanation the very opposite to a mechanical one. It is a metaphysical hypothesis of the existence of immaterial principles, which not only move matter directly, but also conserve its motion, or re-create the motion which is lost because of friction. It is because of this metaphysical assumption that we can understand Newton's refusal to believe in material forces acting at a distance, even though such action is mathematically proved. It is because it is not material force but immaterial force which moves and acts upon matter without any material medium between them, the medium being also immaterial, i.e., space. It is God, as an agent, acting through a medium of space upon matter, space being the "*Sensorium of God.*" But about these metaphysical

causes we have no mathematical or experimental proof.

This explanation, if accepted at all by Newton, was accepted only dogmatically, as that of the existence of God, because he felt that proof of the metaphysical causes is only possible as a result of, or comes at the end of, complete scientific knowledge. And because of this Newton was cautious. While he was willing to approve the unqualified statements of his followers on this point, he would rather not commit himself, even if his own convictions were strong. His scientific temper and his own character would not allow him to become fully responsible for theories which he could not prove. His whole theological thinking, his studies in Jacob Boehme, William Yworth, and others of that type, his own associates and followers, all of them cried for proof of, for an expression of, a theological, theistic world. They demanded once for all the overthrow of all physics which would make atheism possible and a development of natural philosophy which would be the indisputable proof of God's existence. That would explain Newton's letter to Bentley in which he says: "When I wrote my treatise (the *Principia*) about our system, I had an eye upon such principles as might work with considering men for the belief of a Deity; and nothing can rejoice me more than to find it useful for that purpose." That hope was founded in Newton's suggestion that inert matter moves freely by immaterial principles by the agency of its Creator and through the medium of space, the *Sensorium of God*, according to a purpose willed by God which could be expressed mathematically in terms of a formula.

In the consideration of the ether, Newton did not show himself to be the same careful scientist we have pictured in the consideration of his other work. None of the presentations of his views on the conception of the ether is satisfactorily definite or final. His opinions of the ether fluctuated, and he himself recognized them as metaphysical hypotheses only, without the standing of an experimental law. At the time they had first begun to take important shape in his mind, he had already been involved in discouraging wrangles about the implications of his optical discoveries, and had made clear the distinction between hypothesis and experimental law, banning the former from the positive pronouncements of science.

An interesting passage which combines his conviction that action at a distance is impossible with reminders of More's philosophy occurs in Newton's third letter to Bentley: "It is

inconceivable that inanimate matter should, without the mediation of anything else which is not material, operate upon and affect other matter without mutual contact, as it must do if gravitation, in the sense of Epicurus, be essential and inherent in it. And this is one reason why I desired you would not ascribe innate gravity to me. That gravity should be innate, inherent and essential to matter, so that one body may act upon another at a distance, through a vacuum, without the mediation of anything else by and through which their action and force may be conveyed from one to the other, is to me so great an absurdity that I believe no man who has in philosophical matters a competent faculty of thinking can ever fall into it. Gravity must be caused by an agent acting constantly according to certain laws; but whether this agent be material or immaterial I have left to the consideration of my readers."

This presents a very interesting insight of Newton. We can readily see how he was being influenced by the thought of his day, his scientific method, and his value of God. However, Newton was not content to leave his conception of the ether to the advance of science, and he finally evolved a more settled theory in which he portrayed the ether as a medium of essentially the same nature as air, only much rarer. Its particles are very small and are present in greater quantity according as they are more distant from the inner pores of solid bodies. They are elastic, i.e., possess mutually repulsive powers, being constantly in the endeavor to recede from one another, which endeavor is the cause of the phenomena of gravitation. The conception, in brief, is that the whole of the physical world may consist of particles which attract each other in proportion to their size, the attraction passing through a zero point into repulsion as we get down to the very minute particles that compose what we call the ether. Thus at one stroke the formation of solid bodies out of the mutual attractions of the larger particles, and the all-pervading ethereal medium with its repulsive endeavors and its variations of density are made quite plausible. It is regrettable that Newton did not allow his disciplined imagination to pursue such suggestions till he had evolved the simplest possible theory of the physical universe as a whole.

We can hardly begin to evaluate the effect of Newton's work upon the human mind until we have examined his philosophy of space and time. Turning to the *Principia* we find that "... space and time are vulgarly regarded as entirely relative, that

is, as distances between objects or events. In reality, there is in addition to such relative spaces and times absolute, true, and mathematical space and time. These are infinite, homogeneous, continuous entities, entirely independent of any sensible object or motion by which we try to measure them"—time flowing equably from eternity to eternity; space existing all at once in infinite immovability. "Absolute motion is the transfer of a body from one part of absolute space to another; relative motion a change in distance from any other sensible body; absolute rest the continuance of a body in the same part of absolute space; relative rest its continuance at the same distance from some other body." Absolute motion is to be computed in the case of any body by mathematically combining its relative motion on the earth plus the motion of the earth in absolute space. "Absolute time can be approximated by equating or correcting our vulgar time through a more accurate study of the celestial motions. It may be, however, that we can nowhere find a genuinely equable motion whereby time may be accurately measured. All motions, even those of which, to the best of our observations, appear quite uniform, may really be somewhat retarded or accelerated, while the true or equable progress of absolute time is liable to no change."

This curious conglomeration of ideas is well criticized by Burt.⁵ Space is immovable by its own essence or nature, that is, the order of its parts cannot be changed. If they could be changed they would be moved out of themselves; thus to regard the primary places of things, or the parts of absolute space, as movable is absurd. However, the parts of absolute space are not visually nor sensibly distinguishable. Hence, in order to measure or define distances, we have to consider some body as immovable and then estimate distances and motions of other bodies in relation to it. Thus instead of absolute space and motion we use relative ones, which is suitable enough in practice, but considering the matter philosophically, we must admit that there may be no body really at rest in absolute space, our adopted center of reference being possibly in motion itself.

Hence, by observation and experiment, we can do no more than approximate either of these two absolute, true and mathematical entities; they are ultimately inaccessible to us. "It is possible, that in the remote regions of the fixed stars, or perhaps far beyond them, there may be some body absolutely at rest; but impossible to know, from the position of bodies one to

another in our regions, whether any of these do keep the same position to that remote body; it follows that absolute rest cannot be determined from the position of bodies in our region."⁶

It is interesting to note in Newton's statements that the doctrine of absolute motion is not opposed to the conception of motion as relative; it simply asserts that bodies do change their spatial relations in such and such precise ways, and that our system of reference is not arbitrary. Now the existence of absolute motions in the sense that bodies change their distance-relations, and that in any direction and with any velocity, implies that there is *infinite* room in which they can move; and the exact measurability of that motion implies that this room is a perfect geometrical system and a pure mathematical time—in other words, absolute motion implies absolute duration and absolute space. But, cautiously enough, Newton observes that space and time "do not come under the observation of our senses."

But thus far alone can we go with Newton; no farther. For note: absolute space and time as thus understood, by their own nature negate the possibility that sensible bodies can move *with reference* to them—such bodies can only move *in* them, *with reference to other bodies*. Why is this so? Simply because they are infinite and homogeneous entities. One part of them is quite indistinguishable from any other equal part. Any position in them is identical with any other position; for wherever that part of position may be it is surrounded by an infinite stretch of similar room in all directions. Taking any body or system of bodies by itself, therefore, it is impossible to say intelligibly that it is either moving or at rest in absolute space or absolute time. Such a statement only becomes meaningful when another phrase is added: *with respect to such and such another body*. Things move in absolute space and time, but *with reference* to other things. A sensible center of reference must always be definitely or tacitly implied.

Now it is clear that Newton did not feel this implication of the meaning of space and time or observe the distinction very closely. For he speaks about the possibility of combining the motion of an object on a ship and that of the ship on the earth *with the motion of the earth in absolute space*; furthermore, in many passages, both in the *Principia* and in the briefer *System of the World*, he discusses the question whether the center of gravity of the solar system be at rest or in uniform motion in absolute space. Since, in his day, there was no way of getting

a definite point of reference among the fixed stars, such a question is obviously unintelligible—the very nature of absolute space negates the possibility of its having any assignable significance. How did Newton allow himself to fall into such error?

The answer to this question lies in Newton's theology. To him space and time were not mere entities implied by the mathematico-experimental method and the phenomena it handles. They had an ultimately religious significance which was for him fully as important: they meant the omnipresence and continued existence from everlasting to everlasting of Almighty God.⁷ Newton, like many men of his day, accepted the belief in the existence of God, dogmatically, sentimentally, passionately. He fought against atheism and materialism at all costs. For Newton no opposition between religion and science existed, anymore than between faith and knowledge. The opposition between religion and science really belongs to a later generation of men. Religious problems to Newton were problems of exposition and apologetics. His dogmatic belief in God involved the conception that the attributes of God are geometrical—eternity and infinity—absolute space and time become divine attributes of nature.

Thus, while the motion of matter follows the general laws of mechanics, the real or final Cause of motion does not, but a Divine Providence creates, conserves, and regulates motion, in order that "bodies may not go off their course." And here we see God as a mechanic, a superannuated mechanic, according to Langdon-Davies⁸—a cosmic plumber, according to Burtt.⁹ It seems rather paradoxical that, after all, Newton's work was expended in proving that God was not quite as necessary to the universe as Newton himself wished to believe. God was placed outside of the universe and his eye constantly roved the physical world seeking "leaks to mend" or worn-out parts to repair.

* * *

The law of universal gravitation was undoubtedly the outstanding work of this outstanding man. But in order to better appreciate the importance of Newton's work for the human imagination, we must consider its effects on human ideas about the universe. First of all, what did Newton's work on gravitation do in the field of science itself? Prior to Newton, science presented a curious hodge-podge of isolated facts that were highly entertaining to man. With Newton, man came to entertain

theories rather than be entertained by the theories—it was as if Newton had gathered together all the isolated scientific knowledge of the time and tied it together in a neat bundle, showing many of the facts to be due to a single cause.

What had Newton done to man's picture of the universe?¹⁰ He had substituted for the chaos of many unrelated things, an order based on law. Ever since the collapse of the medieval picture there had been no real order; now order came back again. But this was a different kind of order from the order of the Middle Ages. Then order existed upon the basis of the moral law. Now there was no moral law involved in the picture, but physical law only. Goodness and perfection fell from man's picture of the universe—leaving only such things as mass, motion and measurable quantities.

And what had Newton done to God? We must remember that the human imagination which had so far culminated in Newton had been, from the first, an attempt to learn about God from the nature of the universe. As the universe was represented by Aristotle, by Copernicus, by Kepler, by Galileo, so was God interpreted to the human mind and it was this thirst for knowledge of God that led to the exploration of the universe. People were accustomed to think of the universe as the creation of an artist, and when they found beauty, form, and symmetry in the universe they were pleased to recognize the perfection of the artist. To Newton the universe was a question of space, time, mass, movement, measurable quantities and so Newton's God was a good mechanic and a sound mathematician.

It is very difficult to evaluate justly the work of this great scientist. He lent his genius to the modern mind and passed on. But science moved forward, and under the guidance of the less pious but more fruitful hypothesis that it would be possible to extend the mechanical idea over an ever wider realm, Newton's successors accounted one by one for the irregularities that to his mind had appeared essential and increasing if the world-machine were left to itself. This process of eliminating the providential elements in the world-order reached its climax in the work of Laplace,¹¹ who believed himself to have demonstrated the inherent stability of the universe by showing that all its irregularities are periodical and subject to an eternal law which prevents them from exceeding a stated amount.¹²

Space, time and mass became regarded as permanent and indestructible constituents of the infinite world-order, while the

notion of the ether continued to assume unpredictable shapes and remains in the scientific thought of today, a relic of animism, still playing havoc with poor man's attempt to think straight about his world. Newton's doctrine is a most interesting and historically important transitional stage between the miraculous providentialism of earlier religious philosophy and the later tendency to identify the Deity with the sheer fact of rational order and harmony. God is still providence, but the main exercise of His miraculous power is just to maintain the exact mathematical regularity in the system of the world without which its intelligibility and beauty would disappear.

REFERENCES

1. Alexander Pope, *Works*, Cambridge edition, p. 135.
2. Langdon-Davies, *Man and His Universe*, p. 146.
3. Oliver Lodge, *Pioneers of Science*, pp. 166-7.
4. Snow, *Matter and Gravity*, p. 98.
5. Burt, *Metaphysical Foundations of Modern Physical Science*, p. 260.
6. Newton, *Principia*, I, 9.
7. Burt, op. cit., p. 287.
8. Langdon-Davies, op. cit., p. 167.
9. Burt, op. cit.
10. Langdon-Davies, op. cit., p. 168.
11. "I have no need for God in my hypothesis!"
12. $\Sigma me^2 \sqrt{a} = \text{constant}$, $\Sigma m \tan^3 \theta \sqrt{a} = \text{constant}$, where m is the mass of each planet, d its mean distance from the sun, e the eccentricity of its orbit, and θ the inclination of its plane.

Selected Reading List

- Berry, Arthur: *A Short History of Astronomy*.
 Brewster, David: *The Life of Sir Isaac Newton*.
 Burt, E. A.: *The Metaphysical Foundations of Modern Physical Science*.
 Eddington, A. S.: *The Nature of the Physical World*.
 ——— *Space, Time, Matter, and Gravity*.
 Grant, Robert: *History of Physical Astronomy*.
 Jeans, James: *Modern Cosmogonies*.
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 Mädler, J.: *Geschichte der Himmelskunde*.
 Newton, Isaac: *Philosophiæ Naturalis Principia Mathematica* (Motte translation).
 ——— *Treatise of Opticks*.
 Snow, A. J.: *Matter and Gravity in Newton's Physical Philosophy*.

NEGRO HISTORY WEEK

The eighteenth annual celebration of Negro History Week will take place February 7 to 14. The schools will have the opportunity to demonstrate what they have learned from the study of the race during the year. For information write to the Association for the Study of Negro Life and History, 1538 Ninth St., N.W., Washington, D. C.

VACUUM TUBE ELECTROSCOPE

ARTHUR B. HUSSEY

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An interesting demonstration piece, simple to construct, and vividly illustrating principles in both static electricity and radio, is the vacuum-tube electroscope. The particular arrangement described here is the simplest known to the writer; it has the further advantage that all parts necessary for its assembly are available in these days of restriction of materials for war needs.

The parts required, as shown in Fig. 1, are: vacuum tube, type 32; 4-prong socket, surface mounting (common in old battery radio receivers); a 2000-ohm 10-watt resistor (or a 7-watt 115-volt lamp, GE Mazda type C-7, 10¢, in a candelabra socket, 10¢); a neon glow lamp, 2-watt such as GE type S14 clear; and Edison-base porcelain socket for this; a grid cap, large, for 32 tube; a foot of radio bus bar or stiff copper wire; cord and plug; base of presdwood or plywood.

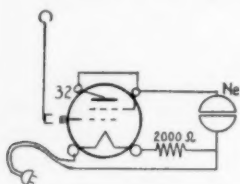


FIG. 1. Schematic Wiring Diagram.

The assembly and wiring are straightforward; there are no wires which must be kept far apart or shielded as in many radio sets. Fig. 2 shows an arrangement that has proved satisfactory. Small holes at F, F, X allow unimportant wiring to be kept back of the panel, while surface wiring is used to make clear to students that the electron flow is actually through the vacuum tube to the neon light.

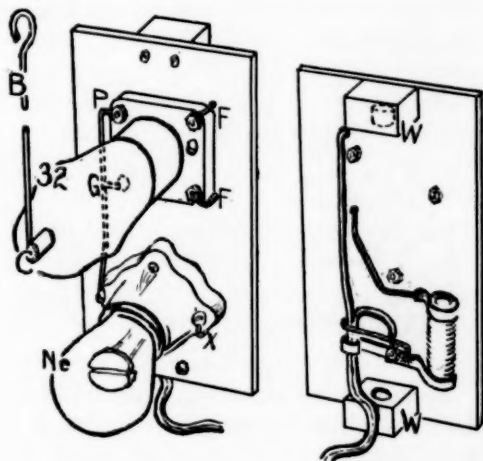
USE IN STATIC ELECTRICITY

For presentation to beginners in static electricity, the circuit of Fig. 3 is sketched on the blackboard. The screen grid is not mentioned, because a knowledge of its function is not necessary to an understanding of the phenomena to be shown. A brief elementary presentation of thermionic emission, the action of a positive plate, and the way in which grid potential controls plate current, is given to the students. The wire on the grid cap of the 32 tube is pointed out, and the facts mentioned that the

filament is heated by the electric-light current, and that current flowing through a neon tube makes *one* of its plates glow as electrons fly off *that* plate and strike the neon atoms in the tube.¹ If a 90-volt B battery is available, this can well be shown by connecting it to the neon tube contacts in the two ways possible.

Upon plugging in the electroscope to the power supply, one of the neon tube plates will glow, showing that current is flowing through it; this must be the current passing as a stream of electrons from hot filament to plate in the radio tube. Now, bring near the wire on the tube-cap a rod carrying a negative charge. The glow becomes faint, as the negatively charged grid hinders the flow of electrons through the tube. A sudden approach, or the

FIG. 2. Front and back views, showing arrangement of parts B, bus bar, bent and soldered to cap C, which slips over cap on top of the 32 tube. W, W, wood blocks for support of panel on a ring stand. The upper is bored only part way through. A 7-watt lamp may take the place of the resistor shown.



use of a strong negative charge, completely extinguishes the glow. When the glow is weak, a positive charge brought near the grid wire will make it noticeably brighter. In cold, dry weather, a charged hard rubber rod six feet from the grid wire will put out the lamp when suddenly moved toward the apparatus.

USE IN RADIO

When presentation of the various functions of the radio vacuum tube is undertaken, the same demonstration, with additions, is interesting. It may be well to repeat the steps in the preceding paragraph. The fact that the grid is charged by elec-

¹ Fink, *Engineering electronics* (McGraw-Hill), p. 192.

trostatic induction may be discussed, and the leakage of electrons from a negative grid observed.

At this time in the course, students will be prepared to appreciate the enormous *amplification* of a radio tube, and to realize clearly that it is a very sensitive relay, not a source of energy. In the case of this experiment, for example, the *work* done in stopping the flow of current through the neon tube—a current producing a watt of power—is only about $1/3,000,000,000$ joule, since a negative grid voltage of 8 volts will stop the plate current, and the charge on the grid necessary to produce this potential is only 42×10^{-12} coulomb. Or, to look at the matter in another way, each electron on the grid controls the passage of 200 million electrons through the tube. (250 million electrons on the grid control a current of .017 ampere, or 5×10^{16} electrons per second.²)

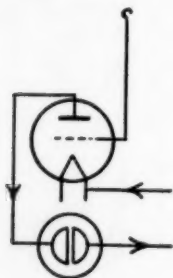


FIG. 3. Fundamental Circuit. Arrows show direction of electron flow.

By supplying the neon bulb with the alternating voltage of the power line, lighting both plates, then showing that current flows in but one direction when the 32 tube is in the line, the rectifying action of the vacuum tube is demonstrated.

The meaning of "grid bias" and its production by a C battery are brought out by connecting dry cells (small flashlight cells are of course sufficient) between filament and control grid. When the grid potential is several volts higher than that of the electron emitter, the filament, the neon light is bright; when the grid is lower in potential, the neon tube current is reduced, and at about -8 volts is cut off completely.

² Reference 1, and RCA *Receiving tube manual*.

When a man disciplines himself to do hard things, he gains a mastery over himself and the world. Success depends on being able to do things one doesn't like far more than on being lucky in finding things one does like. The man who can do only what he likes has narrowed his path of achievement to the breadth of a rabbit run.—*Ex.*

LET'S TEACH NATIONAL PARKS

G. D. McGRATH

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I talked with one of our great American soldiers yesterday. He was a typical specimen of the good effects of army training, and one could always listen eagerly to what he had to say.

But one thing he said impressed me more than anything else. He exclaimed with contagious exuberance, "I've just spent the most wonderful week of my life! I've been on furlough and my folks took me for a week's relaxation to a national park in my home state. We had nothing to do but enjoy to the fullest extent the magnificent beauty and recreational opportunities provided and protected for all of us there. It's true that just being with my folks again was responsible for much of my enjoyment, but I don't want to minimize the part that being in the park played. Actually, I never knew before that such places existed! Why didn't we ever learn about these places in school? That makes just one more thing worth fighting for!!"

I came away feeling almost sad, wondering how many others had never become acquainted with what our national parks have to offer. I wondered if the parks had served their purposes for a sufficient number of people and if people really had been making maximum use of them. Perhaps the soldier was right—they really are something else worth fighting for. Thereupon, I decided to find out a little more about them.

In general, the parks occupy the most scenic spots accessible and are established and maintained for the enjoyment and pleasure of all of us. There are about thirty of them and several additional areas are or have been under consideration. Most of them have excellent facilities for their guests.

It might seem a little out of place to stress teaching about national parks at a time when travel facilities are seriously limited. Even so, it would be well to provide more knowledge about them so that when the first opportunity arises, more people can go to such an area to re-establish their mental composure after the effects of a war torn nation have been so evident.

The problem of placement in the curriculum naturally arises. Logically, a unit of the national parks should be included in geology or physical geography. But since so many schools do not offer these subjects, if such a unit is to be offered, it might

easily be incorporated into some other course. Many schools are successfully working in a study of the national parks in an *America Appreciation* unit in the social sciences. A few are including it in guidance areas. There are also other places in the curriculum where a place may be found for a study of the national parks, but, in general, it is a part of the science department, or should be promoted by the science department.

A number of educators have asked where materials for a unit on the parks may be obtained. There are many sources. Booklets about many of the national parks have been furnished free upon request to the National Park Service, Washington, D. C. In many instances, railroads are glad to furnish excellent pictures and booklets about parks which their lines serve. There are dozens of rental films available which show the parks advantageously. A number of schools report that they arrange an exchange with pupils of a school near a national park through which they send items of interest from their localities in exchange for materials or souvenirs from the park area. One school reportedly sends samples of minerals and rocks from the park area with a brief description of each. The government has a large number of rather inexpensive publications having something to do with the parks. It is also possible to collect pictures from the parks via mail at very low cost. Many classes save and mount pictures taken from national parks which occur in rotogravure sections of Sunday newspapers. In addition, quite a sizeable library can be built up of reference books, travel books, and interesting nature stories having connection with a park or parks. The author has been able to build up a reference book list of nearly 200 excellent books for use in a study of the parks.

Some of the parks report that many schools have been making field trips to their areas for many years. Every effort is made to make their visits profitable and one park reports that entrance fees are not charged the students under these conditions.

In addition to the scenery and facilities for recreation, other worthwhile knowledge might well be included in a study of the parks. Many of them have an interesting history and in some cases have had a part in political developments. Frequently, museums can supply further material along these lines. Some of the parks supply strategic or important minerals, ores, or other economic products. A little geology explaining their origin and development would be of interest and worthwhile even for the non-geology student.

It may be that our schools feel overburdened as it is. Stress has been placed on so many vital contributions which the schools must make in these crucial times. Under periods of such tension, we, as educators, are likely to overlook some of the smaller but important contributions while faced with some of the larger problems. But in spite of the multitude of exigencies created by the war, let's do one more thing—let's teach national parks!

A SIMPLE POPULATION FORMULA OF USE IN TEACHING GENETICS

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In the teaching of elementary genetics only casual reference is made to hereditary changes in population. These references usually take the form of general statements on the elimination of unfit stock through natural selection in evolution, and through artificial selection in eugenics. The student mind is more impressed by, and more likely to retain, information when supported by concrete examples.

It is common usage in biology teaching to present the example of the Kallikaks and the Jukes as horrible examples of eugenic breeding. The statement is generally made that all people who are hereditarily feeble-minded should be restrained from producing offspring. The objection then arises that since only homozygous recessives are phenotypically evident, feeble-mindedness cannot be completely eliminated through artificial selection against these recessives. The objection is resolved by pointing out the decrease in proportion of recessive gametes and of heterozygotes and recessive phenotypes as generations pass under artificial selection. If at this time a formula were introduced which gave the exact amount of subsidence of the recessive, the point would be much stronger.

Another situation is often used as an example of natural selection is that of the homozygous recessive which is lethal, abortive, or unable to exist under normal conditions, as, for instance, albino corn. In this case a demonstration of corn showing the 3:1 ratio is usually presented to classes. This often unconsciously leaves the impression that if such corn were growing

wild, a 3:1 balance would obtain in the population for all generations.

The following formula demonstrates the reduction of recessives beginning with a population at equilibrium. In the derivation of this formula, the parental generation will therefore be taken as being heterozygous. In calculating the ensuing generations the homozygous recessive is eliminated in all cases as lethal, abortive, or by selection.

Generation	Ratio of dominant to recessive zygotes	Gametes	Dominant zygotes	Ratio of homozygous dominant zygotes to dominant heterozygotes
P			$AaAa$	
F_1	3:1	$(1A:1a)^2 =$	$1AA:2Aa$	1:2
F_2	8:1	$(2A:1a)^2 =$	$4AA:4Aa$	2:2
F_3	15:1	$(3A:1a)^2 =$	$9AA:6Aa$	3:2
F_4	24:1	$(4A:1a)^2 =$	$16AA:8Aa$	4:2
F_5	35:1	$(5A:1a)^2 =$	$25AA:10Aa$	5:2
F_{10}	120:1	$(10A:1a)^2 =$	$100AA:20Aa$	10:2
F_{100}	10,200:1	$(100A:1a)^2 =$	$10,000AA:200Aa$	100:2

By inspection it is obvious that if n is taken to represent the number of filial generation (F_n) then:

The ratio of dominant to recessive gametes produced by generation $F_n = (n+1):1$

The ratio of homozygous dominant zygotes to heterozygotes in generation $F_n = n:2$

The ratio of dominant zygotes to recessive zygotes in generation $F_n = n(n+2):1$

MICA CONCENTRATION PROCESS

On a new process for the concentration of the highly critical war material, mica, out of mixtures of earth and rock debris, patent 2,303,962 was awarded to Francis X. Tartaron and Allen T. Cole of Mulberry, Fla., assignors to Phosphate Recovery Corporation of New York. Their process improves on the current froth-flotation method by the addition of lime, magnesium carbonate or other alkali-earth compound to the customary soapy-resinous bath that sorts the precious glittering particles out of the worthless dross with which they are mixed.

NOTES FROM A MATHEMATICS CLASSROOM

JOSEPH A. NYBERG

Hyde Park High School, Chicago

(Continued from the December issue)

34. "Rate of Work" Problems in Algebra. I refer here to problems like:

A can do a job in 10 days; B can do the same job in 8 days. How long will it take them if both are working?

The usual textbook way of solving such problems is to let x be the required number of days for the two men, and to derive the equation $\frac{1}{10} + \frac{1}{8} = \frac{1}{x}$.

When this method is used, how shall a pupil solve:

A can do a job in 10 days; B can do the same job in 8 days. After A has been working alone for 3 days, he hires B to help him. How soon thereafter is the work finished?

Most teachers would consider this problem too difficult for ninth graders and would suggest that we skip it. But both problems can be solved by a single general method if the pupil first learns two simple relations about rate of working.

1. What a man accomplishes equals the number of days he works multiplied by what he accomplishes in one day.

2. What one man accomplishes added to what a second man accomplishes equals the total of their accomplishments.

In a previous issue (item 11, April, 1942) I discussed how a pupil's failure to solve a problem often depends on such apparently trivial relations, which the book does not mention but which a pupil is expected to know.

The problems could be treated as follows:

The first problem should be solved by arithmetic. If A can do the job in 10 days then in one day he does $\frac{1}{10}$ of the work; likewise, in one day B does $\frac{1}{8}$ of the work. Hence, together they do $\frac{1}{10}$ plus $\frac{1}{8}$ or $\frac{9}{40}$ of the work. To do $\frac{40}{40}$ of the work will require $\frac{40}{9} \div \frac{9}{40}$ or $4\frac{4}{9}$ days.

Problems of this kind are often asked on examinations for mail carriers, shop foremen, and many civil service examinations where candidates are not expected to have studied algebra but are expected to know elementary arithmetic. The teacher should emphasize that in problems of this kind the attention must be centered on: what part of the job is accomplished in one unit

of time, i.e., what is the rate or speed with which the work is being performed.

A pupil may ask, "Can the problem be solved by algebra?" If the question does not arise, the teacher may well propose it. In that case, we begin as usual with:

Let x be the number of days each man works.

Then A's contribution or share of the work equals the number of days he works multiplied by what he accomplishes per day. This is x times $\frac{1}{10}$ or $\frac{1}{10}x$. There is good reason for writing $\frac{1}{10}x$ not $\frac{x}{10}$ because we are multiplying the number of working

days by the daily accomplishment. To a teacher $\frac{1}{10}x$ and $\frac{x}{10}$ are the same; to a pupil there is a big difference. One is product. The other is a quotient of days by days, and its meaning is more difficult to interpret. (See item 5, Feb. 1942 on the value of interpreting each term of an equation.)

B's contribution is x times $\frac{1}{8}$ or $\frac{1}{8}x$ not $\frac{x}{8}$.

Then, using relation 2 above, we write $\frac{1}{10}x + \frac{1}{8}x = 1$.

To a mathematician this is equivalent to $\frac{1}{10} + \frac{1}{8} = \frac{1}{x}$. But note what a big difference there is if we change the problem so as to ask: How many days will A and B need to do $\frac{1}{3}$ of the work, instead of all the work. Relation 2 says at once that in this case $\frac{1}{10}x + \frac{1}{8}x = \frac{1}{3}$.

Consider next the problem in which A begins alone and works 3 days before calling on B for assistance. According to the method that I suggest, we write

A works $x+3$ days; B works x days. Then $\frac{1}{10}(x+3) + \frac{1}{8}x = 1$ and we have solved both problems by the same method. There was nothing new for the pupil to learn. The whole process hinges on making the pupil conscious of relation 1 and 2.

We speak of mathematics as being a study of relations or functions. Too many of the examples that we use seem trivial to a pupil. Much Ado About Nothing, he would say if he had ever heard about Shakespeare. We need better examples, and one of the best is this one about the rate of working.

35. Different Problems Can Be Similar. Another reason why I like the *rate of working* problems is that I can use them to show that many problems seem different but are alike in their functional relations. For example,

Tom and Jim run around a circular track in opposite directions. Tom can run around the track in 10 minutes but Jim needs only 8. How soon after they start does Jim pass Tom?

If we think of running around a track as work to be done, and the job to be accomplished is the making of one lap, then we have the same equation: $\frac{1}{10}x + \frac{1}{8}x = 1$.

But suppose they run in the same direction. Then the fast boy gets ahead of the slow one, and when the fast one catches up to the slow one, the fast boy will have run one more lap than the slow boy. In a given number of minutes, m , the slow one will have run m times $\frac{1}{10}$ laps. The fast one will have run m times $\frac{1}{8}$ laps, which is 1 lap more than the other boy has run. Hence $\frac{1}{8}m = \frac{1}{10}m + 1$.

Consider next an astronomical problem. Mercury and the earth were in inferior conjunction on Oct. 11, 1942; what is the approximate date of the next inferior conjunction?

After explaining what is meant by inferior conjunction, the pupil sees that this is the same problem as that of two boys running around a track in 365 and 88 days respectively, going in the same direction. Hence $\frac{1}{88}d = \frac{1}{365}d + 1$.

An apparently different problem is: How soon after 3 o'clock will the minute hand and hour hand point in opposite directions? Again we have two boys running around a track in the same direction. The fast boy can do a lap in 60 minutes; the slow boy does it in 720 minutes, but he has a quarter of a lap start and is half a lap behind the fast boy when the whistle blows. Hence he really runs $\frac{3}{4}$ of a lap less than the other boy. Then $\frac{1}{60}m = \frac{1}{720}m + \frac{3}{4}$.

After having a class work a clock problem in this manner I like to emphasize that problems are solved by writing some relation between the *numbers* in the problem. The emphasis in the preceding sentence should be on the word *number*. For example, let us solve the clock problem in a different way. I draw a picture of a clock showing the position of the hands at 3 o'clock and when the hands next point in opposite directions, putting the letter A at 12 o'clock and the letter B at the end of the minute hand in its final position. Then I write on the board: It is as far from A to B, counting clockwise, as it is from A to B. The pupils laugh at that statement and wish to contribute a few statements of their own such as: the long hand is longer than the short hand, a clock is round, or clocks hang on walls.

But my statement is of no value until I can say it with num-

bers. I must find some way of saying how far it is from A to B. It must say it in numbers. I must measure how far it is from A to B. Shall I use inches, miles, gallons or degrees? We finally decide on using minutes. Then the number of minutes from A to B is m , and is also $15 + \frac{1}{12}m + 30$. Hence $m = 15 + \frac{1}{12}m + 30$. If degrees are mentioned as a unit of measurement I assign as a problem for the next day, the task of writing the same idea using degrees, and offer as a hint that there are 90 degrees between 12 and 3 o'clock, and so forth.

But the important item in the lesson is that most statements are of no value until they are stated in numbers. A poet may talk about the beauty of a sunset, but a mathematician who overheard him would say, "How do you say *beauty* in numbers?" When a history teacher says that Napoleon was a great general, the pupil should say, "How do you say that with *numbers*?" When the Social Studies teacher says, "The community needs more playgrounds," the pupil should say, "Say it with numbers." That is what curriculum reports mean when they write that pupils should learn to think quantitatively.

36. The Value of Verbal Problems. For some time verbal problems have suffered from taboo on the grounds that they were mere puzzles and of slight practical value. To find A's age you should examine his birth certificate; to find the number of nickels he has, examine his purse; to find when the hands of his watch are parallel, you merely turned the hands until they were parallel. Many teachers welcomed the news since the teaching of these problems requires considerable skill and the results often seem meager.

In the place of verbal problems the teacher stressed the formal operations (and was dismayed when reports suggested that only simple exercises need be taught); they drew graphs (and used them to find the cost of 3 lb. of sugar at 6¢ a pound); they introduced informal geometry (and were annoyed when sophomores afterwards asked why they should prove what they already knew).

A good defense of verbal problems is found in Butler and Wren's *Teaching of Secondary Mathematics*, p. 318.

If we wish to erect new structures we must have definite knowledge of the old foundations.—CALVIN COOLIDGE, Inaugural Address, 1925.

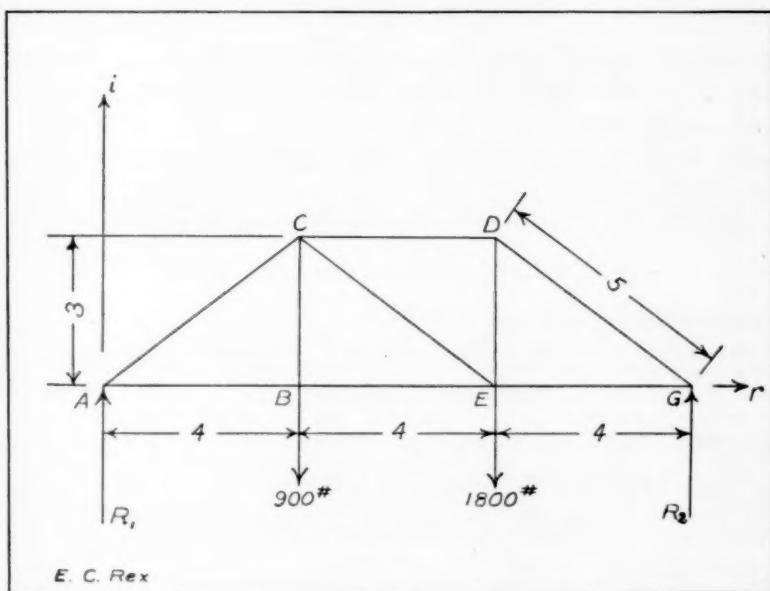
TWO APPLICATIONS OF MATHEMATICS TO ENGINEERING AND PHYSICS

EARL C. REX

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Your classes can be enriched and your students filled with a new enthusiasm for mathematical sciences by some well-chosen applications to engineering and physics. Many of these are not found in textbooks and are not well-known.

Students often wonder, for example, what use can be made of the imaginary numbers. One use is in an analysis of bridge structures; it employs a simplified modification of a method used in a previously published article.*



To illustrate: A small bridge has the structure and dimensions shown in the diagram. All lengths are in yards, all weights in pounds. R_1 is found to be 1200 lbs. by taking moments about G , and R_2 is 1500 lbs. The weight of the bridge is negligible. If it were too large to be neglected, the weight should be distributed appropriately among joints A , B , E , and G . The vertical axis is

* Rex, Earl C. *Forces on Struts Determined by Analysis*. Jan. 1941 (41: 15-17).

the axis of imaginaries, the horizontal is the axis of reals. Upward and to the right are respectively the positive directions on the axes. The geometric sum of the forces at each point equals zero, because the system is in equilibrium. Thus at A , R_1 is 1200 lbs. acting upward. To balance this, the member AC pushes downward and to the left. Because of the slope and direction of this push, its components should be written

$$-\frac{4}{5}F_1 - \frac{3}{5}F_1i$$

where F_1 is the force exerted by CA and $i = \sqrt{-1}$. Then

$$1200i - \frac{4}{5}F_1 - \frac{3}{5}F_1i$$

is the algebraic sum of R_1 and F_1 . But this is obviously not zero; hence there must be another force acting at A . This is the horizontal force F_2 exerted by the member AB . Therefore:

$$1200i - \frac{4}{5}F_1 - \frac{3}{5}F_1i + F_2 = 0.$$

From this, equating the sum of the imaginaries to zero, we find that $F_1 = 2000$. Equating, also, the sum of the real terms to zero we find $F_2 = 1600$.

At B the force of $BE = F_3 = 1600$, and the force of $BC = F_4 = 900$.

At C let the force of $CE = F_5$ and that of $CD = F_6$:

$$1600 + 1200i - 900i + \frac{4}{5}F_5 - \frac{3}{5}F_5i - F_6 = 0$$

from which $F_5 = 500$ and $F_6 = 2000$.

At D designate the force of DG by F_7 and that of DE by F_8 ;

$$2000 - \frac{4}{5}F_7 + \frac{3}{5}F_7i - F_8i = 0$$

and $F_7 = 2500$, while $F_8 = 1500$.

At E represent the force of EG by F_9 :

$$-400 + 300i + 1500i + F_9 - 1800i - 1600 = 0$$

and $F_9 = 2000$.

At G :

$$-2000 + 2000 - 1500i + 1500i = 0,$$

which checks.

Variations in the dimensions and weights on the bridge may be made. If the weights at B and E are equal, the middle diagonal CE should be omitted. If the weight at B is greater than at E the diagonal member should be between B and D . In actual

construction, both diagonals are present; but when the weight is greater at E , then the diagonal BD (which is a thin rod) goes slack, and vice versa.

A number of fascinating applications may be shown by the use of differentials of very elementary algebraic functions. A simple illustration is afforded when measurements of the three dimensions of a block $1" \times 5" \times 11"$ are taken. Suppose the maximum error in measuring the $1"$ side (say, by a micrometer) is $0.0002"$; in measuring the $5"$ side (say, by vernier calipers) is $0.002"$; in measuring the $11"$ side (say, by a foot ruler) is $0.03"$. The problem is to find the maximum possible error in the computed volume.

Taking differentials in the formula $V = lwt$ we have $dV = lwdt + ltdw + wtdl$, and substituting the values for these symbols we obtain:

$$dV = 11 \times 5 \times .0002 + 11 \times 1 \times .002 + 5 \times 1 \times .03 \\ = .011 + .022 + .15 = .183.$$

$$\therefore V = 55 \pm 0.183 \text{ cubic inches.}$$

This last expression also shows the notation for tolerances.

The student can be shown briefly how he may use this technique to determine his maximum possible error in many of his physics experiments.

NO FREEDOM WITHOUT EDUCATION

Despite all obstacles, . . . even because of these obstacles, every boy and girl, every young man and woman, who can possibly do so should go to high school or college this year. If there were no war, if times were perfectly normal, this would be true. Modern life—economic, social, civil, political, spiritual, cultural—demands universal education of a high order and of many kinds. . . . Individual and public welfare depend on education. Individual and public health, material wealth, civic righteousness, political wisdom, spiritual development and the sweetness and light we call culture all wait on education. Democracy is not possible without it—neither political, social, economic, or religious democracy. "There can be no freedom without the education of man."

In our economy the schools, high schools, colleges, and technical schools are practically the only source of educational supply. It therefore quite certainly becomes not only a high patriotic duty but a military necessity that all these schools be maintained at fullest efficiency, and that all who can shall take fullest advantage of the opportunity of education and training they offer. Full schools now may contribute more toward final victory than could possibly be contributed by emptying the schools and sending all these young men and women into some form of immediate, direct, or indirect war service.—*P. P. Claxton.*

EASTERN ASSOCIATION OF PHYSICS TEACHERS

ONE HUNDRED FIFTY-FIRST MEETING

BROOKLINE HIGH SCHOOL

115 Greenough St., Brookline, Massachusetts

Saturday, October 17, 1942

PROGRAM

- 9:15 Greetings by Mr. Wilfred H. Ringer, Headmaster of Brookline High School.
- 9:30 Address: "The Turbo-Supercharger."
Dr. Sanford A. Moss, General Electric Engineer and pioneer in the development of the turbo-supercharger.
- 10:30 Address: "Aviation Meteorology."
Professor James M. Austin, of the Department of Meteorology, Massachusetts Institute of Technology.
- 11:30 Address: "Effect of Aviation on the Science of Navigation."
Mr. Robert Reynolds Sweeney, Rindge Technical School.
After the meeting the science laboratories of the high school will be open for inspection.

The Executive Committee has thought it desirable to revive a former policy of the Association and hold five meetings this year. The other meetings will be as follows: December 5, at Simmons College (a joint meeting with the Chemistry and Biology Associations with the theme of the meeting, "New Materials in Industry"), February 13, April 10, and May 22.

Members are also reminded of the meeting of the American Association for the Advancement of Science, to be held in New York the week after Christmas. The program will be announced more in detail at the December meeting.

Officers:

President: Alfred C. Webber, High School, Brookline, Mass.
Vice-President: Clarence W. Lombard, High School, Hyde Park, Mass.
Secretary: Carl W. Staples, High School, Chelsea, Mass.
Treasurer: Albert R. Clish, Belmont Junior High School, Belmont, Mass.

Executive Committee:

Hollis D. Hatch, English High School, Boston, Mass.
Charles S. Lewis, Brighton High School, Brighton, Mass.
Louis R. Welch, Dorchester High School for Boys, Dorchester, Mass.

BUSINESS MEETING

The following were elected active members of the Association.
Mrs. Harold Ray Colson, Cambridge High and Latin School, Cambridge, Mass.
Mr. Anton Kishon, Phillips Academy, Andover, Mass.
Mr. Robert C. Hall, Brookline High School, Brookline, Mass.

SUPERCHARGERS FOR AVIATION

SANFORD A. MOSS

An airplane engine is driven by explosions of charges of gasoline and air. These charges are mostly air, which is sucked in from the atmosphere as the engine pistons move back and forth. At altitudes above sea-level the atmospheric air gets thinner and thinner, so that the charges that are sucked in amount to less and less as an airplane flies higher and higher.

During the last war it occurred to some engineers to *push* into the airplane engine cylinders, bigger charges of air than were being obtained by sucking from the atmosphere. This soon was found possible, and so the supercharger came into use.

The modern supercharger has a rotary wheel, called an impeller, of the same general nature as the rotor of a fan blower. However, the supercharger impeller rotates at a very much higher speed and has a more complicated design than any ordinary fan blower. This supercharger impeller is driven either by gears from the engine crankshaft or, in the case of the turbosupercharger, by a turbine wheel driven by the exhaust gases of the engine. The design of the impeller and its casing, the means of driving, the multiplication of effect by having several impellers in combination, high-speed turbine wheels driven by red-hot exhaust gases, and similar items are technical details which have been the subject of great research, but which need not here be elaborated upon. I have had a lot of fun in participating in this research from the beginning, in collaboration with other engineers of the General Electric Company and of the Army Air Forces. The net result is compression of the atmospheric air so as to push such an increased amount into the airplane engine that the power is greatly increased at all altitudes.

The effect of the supercharger in thus pushing increased charges into the engine is being made of service in three ways.

First: Maintenance of the power at the same amount as it would be at sea level, as the airplane engine flies higher and higher. Otherwise, the engine power would decrease in proportion to the decreased air density, so that it would be cut in half at about 20,000 feet altitude, with further decreases at higher altitudes.

Second: Increase in the amount of charge at sea level, so that a given engine will give an increased amount of power. This may vary from an increase of 25% or so for short intervals, to greater increases for longer times, all depending upon the design details.

Third: By a combination of these two items, so that at all altitudes an engine will give the same increased amount of power as was possible at sea level.

During World War I, the possibilities of superchargers began to be developed, but there was no actual use. After the war, the supercharger research was continued, and about 1920 a number of sorts of superchargers began to be used to a small extent. This use slowly increased to about 1925

when it began to be evident that the supercharger was worth serious attention. About 1930 practically all aviation engines had a geared supercharger built in as an essential part of the engine structure. Similar advances were made with turbosuperchargers driven by engine exhaust gases. About 1940 these turbosuperchargers were being used to a very large extent in United States military planes.

Every advance in the use of both geared and turbosuperchargers, obtained by engineering research and practical applications, has given an appreciable increase in engine performance. As is always the case with every sort of engineering research, this process will continue, and new refinements, new extensions, and new principles will be introduced into the supercharging art. It seems certain, therefore, that supercharging of one sort or another will form a more and more important part of aviation progress, both for commercial and military airplanes.

The exact nature of these expected refinements and extensions can hardly be predicted at the minute. And even if they could be predicted, they would not pass military censorship. But, it seems certain that the progress which has been made, from zero in 1918 to enormous use of superchargers in 1942, will continue to an accelerated extent in the future.

Of course, the supercharger is only one of the many sorts of things which are undergoing intensive development in aviation at the present time. All of these will result in increased performance of airplanes, and increased use, both from a commercial and a military point of view.

AVIATION METEOROLOGY

PROFESSOR JAMES M. AUSTIN

INTRODUCTION

It is typical of many weather phenomena that they develop around an indifferent or unstable state of equilibrium, so that a small impulse may give rise to great events. The same is true, to a certain extent, of the development of the theory and practice of weather forecasting. It was a storm and a war in Europe which gave the impulse that initiated weather forecasting.

On Nov. 14, 1854, during the Crimean War, a hurricane destroyed a large portion of the Allied fleets in the Black Sea and resulted in the loss of the French battleship "Henry IV." The Emperor of France, Napoleon III, then decreed that the scientists should invent ways and means of predicting the weather phenomena. This truly ungrateful task of making the first attempt to predict winds and weather was given to the French astronomer Le Verrier.

A few years previous, Le Verrier had become world famous because of an outstanding feat in the field of astronomy. He had predicted the existence of a planet which no one had ever seen. He did not use a telescope to dis-

cover this planet; he used mathematical equations and Newton's law of gravitation.

Through purely theoretical considerations Le Verrier came to the conclusion that an unknown planet existed within the solar system, and he computed where the planet would be on a certain night. Professor Galle in Berlin directed his telescope to the spot indicated by Le Verrier and, behold, there was the planet. They called it Neptune.

The Emperor of France apparently thought that if Le Verrier could forecast the movement of an unknown planet, then he should most certainly be able to forecast the storms. Le Verrier attacked this problem and he was chiefly responsible for the introduction of the daily synoptic weather map.

In view of later experience, however, it is now safe to say that the problem of computing the formation and the movement of a storm is vastly more difficult than the problem of computing the movement of an unobserved planet.

GENERAL ASPECTS OF METEOROLOGY

The sun may be regarded as the sole source of energy that is supplied to the earth's surface and the atmosphere. The ultimate cause of all changes and motions in the atmosphere may, therefore, be sought in the energy radiated from the sun.

Radiation studies show that there is a net surplus of heat received by the atmosphere in low latitudes and a net loss of heat from the atmosphere in high latitudes. To compensate for this unequal distribution of radiative energy there must be a transfer of heat from low latitudes to high latitudes. This transfer is accomplished principally by the large-scale air currents in the lower atmosphere.

A direct and simple south to north wind circulation could effect the heat transfer. However, such a circulation scheme is dynamically impossible. Instead we find that the transfer is accomplished principally by means of a complex pattern of migratory pressure systems. The low pressure systems are called cyclones, and the high pressure systems anticyclones. The broad-scale features of our weather can be directly attributed to the physical processes which accompany the development and movement of cyclones and anticyclones.

Let us briefly consider some of these weather phenomena. First, to the aviator wind is an element of vast importance. The meteorologist can forecast changes in wind direction and velocity by applying the laws of motion to the atmosphere. The complete solution, however, is very difficult, due to the fact that air motion is influenced by the distribution of pressure, the roughness of the ground, the force of gravity, the curvature of the air particle's path, the effect of the earth's rotation, etc. On the other hand, sufficiently accurate wind forecasts can be made by the introduction of reasonable approximations and assumptions.

The formation of clouds, rain, snow, fog and other hydrometeors are the

result of a great number of processes which are continually taking place in the atmosphere. In general we can classify such weather phenomena as either frontal or air mass. The general circulation of the atmosphere has a tendency to produce vast masses of air whose physical properties are more or less uniform over large areas. We find large areas of cold air masses and other areas of warm air masses. The narrow region of transition between a cold and a warm air mass is called a frontal surface. All frontal surfaces are inclined to the horizontal at an angle of about 1:150 in such a manner that the warmer and lighter air rests above the colder and denser air, as illustrated in Fig. 1. Furthermore, the motion at a frontal surface causes the

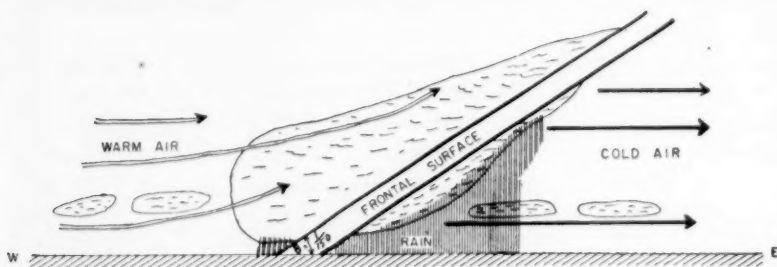


FIG. 1. A vertical cross-section through a frontal surface. The speckled areas indicate clouds and the arrows represent wind motion. This is a warm front moving from west to east.

warm air to ascend. This forced ascent results in a cooling of the air so that condensation takes place. Consequently, fronts will be regions of cloudiness and precipitation. Frontal surfaces are also integral parts of a cyclone in middle and high latitudes, as shown in Fig. 2.

Rain and cloudiness frequently occur within air masses. In the atmosphere the temperature usually decreases with elevation. However, if the decrease exceeds a critical value the atmosphere will be in an unstable state of equilibrium and the accompanying vertical currents may produce cloudiness. For example, the summer afternoon shower arises from the instability which results from the intensive heating of the lower atmosphere. It would require many pages to discuss all types of cloudiness and precipitation, and therefore the previous illustrations should be considered to be only simple examples of weather phenomena.

FORECAST PROCEDURE

It should be borne in mind that the problems which face the airway forecaster are related and similar to those which confront our local Weather Bureau officer. In general, the forecast procedures are quite similar.

For aviation operation the meteorologist must forecast temperature, wind direction and velocity, amount of cloudiness, height of the cloud base and cloud top, rain, snow, visibility, fog and such hazards to flying as thunderstorms and aircraft icing. These forecasts must include the weather

not only at the ground but also at 10 or 20 thousand feet above the earth's surface. The forecast should also indicate the change in each weather element with time.

In order to make these forecasts, the meteorologist refers to a series of synchronous weather maps which have been constructed to show the weather elements at various levels in the atmosphere. The construction of a 10,000 ft. chart, for example, is made possible by the widespread use of radio-sounding balloons which transmit to the observation station a continuous record of temperature, pressure and humidity. The upper winds are also obtained by the use of hydrogen-filled balloons. After the data has

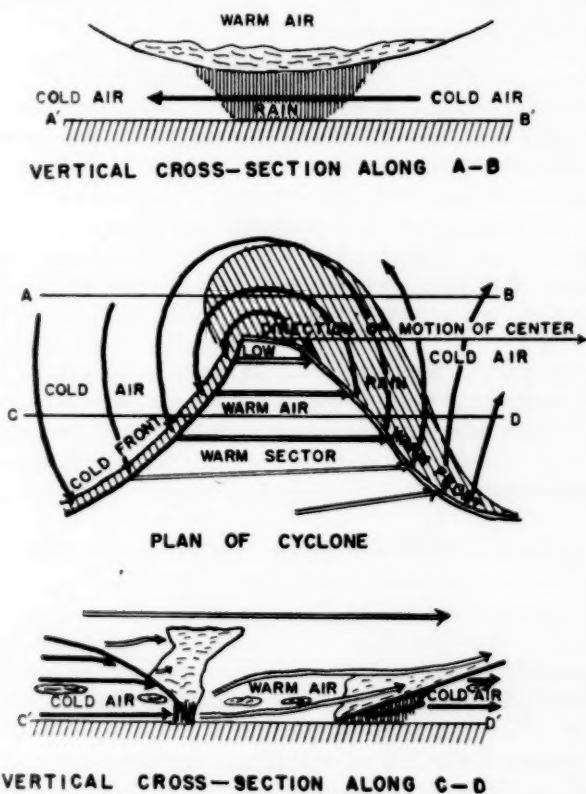


FIG. 2. The Cyclone Model. The central diagram shows the ideal arrangement of air masses and fronts within a cyclone.

been plotted on the various charts, each one is analyzed. By the term "analysis" we mean the drawing of isobars (lines of equal pressure) and fronts (the lines of intersection between frontal surfaces and constant level surfaces, e.g., the ground).

When the analysis is completed the forecaster must then apply his quan-

titative and qualitative rules in order to determine the future movement and changes in structure of the various fronts and pressure systems. He must also investigate whether the air masses are becoming increasingly stable or increasingly unstable. After having determined the general features of the future weather map, the weather forecaster can then dictate his forecast.

This technique of air mass and frontal analysis is usually applicable only for a forecast period of about 36 to 48 hours. Because fronts are frequently formed and destroyed within a few days, it is not yet possible to successfully employ the same technique in long-range forecasting. In view of the importance of long-range forecasts, considerable research is being undertaken on this aspect of meteorology.

IMPORTANCE OF WEATHER FORECASTING

In conclusion we might briefly consider the importance and future of weather forecasting. Already in this war we have read of a number of occasions where the weather has been of vital importance. For example, the loss of two British battleships, the *Prince of Wales* and the *Repulse*; the escape of the German warships through the English Channel; the successful U. S. Naval operations in the South Pacific; in fact, the planning of practically every military operation, whether it be on the sea, the land or in the air, requires a consideration of the probable weather which will be encountered.

As to the future of weather forecasting we can say that our science is still in its infancy and many advances will have to be made before really accurate and precise long-period forecasts are possible. Since weather forecasting is as essential in peace-time as in war, it seems as if meteorology is a field which offers many opportunities to the science student.

THE EFFECT OF THE AIRPLANE ON THE SCIENCE OF NAVIGATION

ROBERT R. SWEENEY

The Phoenicians were the first navigators. Far and wide they ranged over the face of the known world plying their calling as traders. And it was this nation of traders that first practiced navigation in a practical manner.

These people actually had a system of piloting and dead reckoning which was ample for the needs of voyages that, although long, were broken up into short stages. Briefly, the ships were guided either by bearings of visible objects or by keeping heavenly bodies on the right or on the left.

The Romans succeeded to the art of the Phoenicians and navigation remained practically unchanged down to the end of the fourteenth and the beginning of the fifteenth century. This was the period when the trade of the world centered around Venice and Genoa. A sea route to the Indies and the far east became a desideratum.

Out of this school of navigators Vasco da Gama stands forth, for he first

rounded Africa and opened the sea route to the East thereby. From such a school Columbus came to Spain with his ideas on the geography of the earth. Navigation had progressed during these Renaissance years to the point where the compass and astrolabe came into common use but the actual working of the science still depended in large measure upon reckoning. This is borne out by the number of new discoveries that were made in the succeeding one hundred years, many of them resulting from the ship being away off her intended course by reason of storms and other phenomena. Not only were ships driven off course, but in many instances the navigator was bewildered and uncertain as to what direction he had been blown.

This is the state in which we find the science of navigation in the latter half of the eighteenth century. It is true that some English and Dutch navigators had compiled tables to aid them in working out positions more accurately but there was often a great divergence in identical data indicating the existence of errors of considerable magnitude.

The task of correlating this data and the compilation of accurate tables to account for the variations of celestial bodies, and the discrepancies between observed and factual data was the self-assigned task of Captain Nathaniel Bowditch of Salem (1773-1838). How well he succeeded is attested by the fact that his work is today the standard work on navigation and is printed by the U. S. Hydrographic Office under the original title, "*The American Practical Navigator*."

Celestial navigation became the accepted method of guiding ships across the ocean wastes for a hundred years thereafter and a shipmaster could tell his ships position with reasonable accuracy practically anytime that a heavenly body could be observed. When, however, observations were impossible, it was necessary to fall back on the older system of dead reckoning.

The invention of the airplane and the invention of the radio somewhat later have left their mark on the study of navigation; in fact they have revolutionized it. Also the development of meteorology which is now the handmaid of navigation has changed the entire aspect of the situation.

We must remember too, that radio has given us not only means of communication, but also the radio compass and radio bearing stations as well as the development of the beam. Where formerly we depended on lights and landmarks to get a bearing, we now are able to determine our position without reference to visual aids. The range of operation has also been increased by reason of the efficiency of these inventions.

Moreover, when we realize that an airplane often travels ten times as fast as a ship we can see that the slower methods of navigation are outmoded. The fact of the matter is that much of the navigator's work is done before the plane leaves the ground. For the pilot and his co-workers, the meteorologist and superintendent of operations lay out a careful flight plan taking into account winds and weather disturbances as well as the means of avoiding, or surmounting these obstacles.

Now when we consider the speed and maneuverability of a modern plane, we see that, except for very long distances, dead reckoning is the most practical method of guiding a plane over strange terrain or waters; understanding, as we do, that we do not have to worry about obstructions or unexpected storms or the several worries that beset a mariner in such a situation.

Despite the emphasis on dead reckoning, celestial navigation is still a very important and necessary part of the study of navigation since it is often the only means a navigator has of checking his position, particularly if unforeseen circumstances cause him to doubt his dead reckoning. But the fact remains that all the flying services lay stress on dead reckoning, and, this being the first year that we have brought forth the teaching of navigation from the obscurity to which it was relegated some years ago, it seems to me that we would do well to be guided by the more simple and practical aspects of this subject. That is to say, we should teach dead reckoning and the practical applications of trigonometry to this type of navigation.

In closing I would like to point out to those who would teach both dead reckoning and celestial navigation that the difficulty in procuring the materials to demonstrate the practical applications of celestial navigation practically prohibits the teaching of the subject except as theory. Therefore the material that could be offered would be so limited as to make the subject dull. But where position can be plotted on graph paper and solutions both graphic and trigonometric may be worked out by the student, the study of navigation has much more appeal.

SMITHSONIAN RESEARCH ADAPTED TO WAR EFFORT

Smithsonian Institution research programs have been adapted to the needs of the country at war. Since the United States was thrust into the conflict by enemy aggression, over 500 scientific problems have been presented for solution by the Institution's specialists. They range through all the sciences, from the workings of machines and weapons in its extensive collections to the languages and customs of South Sea Island tribes.

This is the fourth war in which the Smithsonian Institution has functioned as an arm of the government. In previous conflicts queries were mainly in the field of mechanics and invention. In this total war, they run through the whole alphabet of the sciences, from anthropology to zoology.

A special committee has been appointed for the coordinating of the scientific war efforts of the Institution's staff of nearly 100 scientists. Under the chairmanship of Carl W. Mitman, historian of inventions, it comprises also L. B. Aldrich, physicist, Wm. N. Fenton, ethnologist, Herbert Friedmann, biologist, and W. P. True, chief of the Smithsonian editorial division.

Despite immediate urgency of war work, the Institution's normal aims of peaceful, constructive research are not being shelved, declares Secretary Charles G. Abbot. Even the programs that have had to be suspended because of the war are left in such condition that they can be resumed as promptly as possible on the return of peace.

THE USE OF FACSIMILES FOR THE TEACHING OF ELEMENTARY MATHEMATICS

HENRY W. SYER
Culver Military Academy
Culver, Indiana

1. USE OF FACSIMILES IN CLASS

There is not enough attention paid in elementary classes in mathematics to the enlivening interest that could be derived from the history of mathematics. One of the best ways to introduce such historical facts and to make them real is by the use of facsimiles of important mathematical works from the past. These can be used in regular class discussion singly as their various subjects are introduced, grouped in historical periods for survey work, or grouped in topical sets for reviews of large units. These groupings may be extremely useful in planning mathematical club programs, for pupils' essays and projects on mathematical subjects, and for the teacher's own use in referring to the sources.

2. METHOD OF COLLECTING EXAMPLES

The following lists of suggested facsimiles which should be available for classroom teachers does not by any means profess to be complete. Such a compilation would be so unwieldy that its length and heaviness would stifle its usefulness.

First, it includes only elementary topics, Trigonometry, college algebra, solid geometry, and calculus are explicitly excluded, but may form the basis for future lists. Second, only key manuscripts and books are mentioned. There has been no attempt to trace the development of a symbol or a process throughout its many editions and variations. Third, most attention has been paid to symbols and processes which are still in use, rather than all blind alleys which were explored and abandoned by early searchers for standard forms. For example, Harriot's use of consonants for known quantities and vowels for unknown quantities, or the process of False Position. Also, forms and words which we are trying to eliminate from secondary use have sometimes been neglected to keep them out of sight until they die their proper death; for example, $3:4::6:8$, and \propto for "varies as." Fourth, since these facsimiles are intended to appeal to teachers and students and to inspire them with a feeling of appreciation of the thought and work that went into

these old symbols, no facsimiles of title pages have been included unless they illustrate something of interest more important than a mere view of the old first edition.

3. PLANS FOR FUTURE DEVELOPMENT

There are two chief ways that these facsimiles can be made available to secondary schools inexpensively, and as soon as funds are made available by some means, the writer would be glad to undertake either of these methods. Photographic, planographic, and photostatic reproductions of these facsimiles could easily be made of large enough size for schools to mount on Bristol board mounts and keep in the art collection or mathematics office to be circulated to the teachers.

The second method is even less expensive and calls for photographing these facsimiles in convenient sets on film strips which can be projected.

The first of these methods has the advantage that the pictures can be arranged in any order, can be used by many pupils or classes at the same time, and can be left on permanent display. The second method, however, has the advantage of very inexpensive duplication, easy control by the teachers, and the possibility of being seen by a large group at the same time.

4. LISTS OF BOOKS

The following books contain facsimiles and will be referred to in the list that follows:

1. Ball, W. W. Rouse; *A Short Account of the History of Mathematics*; London, 1888.
2. Bosmans, H., S. J.; *La "Thiende" de Simon Stevin*; Antwerp, 1924.
3. Breasted, J. H.; *Ancient Records*; Egypt.
4. Brown, R.; *A History of Accounting and Accountants*; Edinburgh, 1905.
5. Cajori, Florian; *The Early Mathematical Sciences in North and South America*; Boston, 1928.
6. ———; *A History of Mathematical Notations*; Chicago (Open Court), 1928. Vol. I, Elementary Mathematics; Vol. II, Higher Mathematics.
7. ———; *A History of Mathematics*; New York, 1894.
8. Chace, Arnold Buffum; *The Rhind Mathematical Papyrus*; 2 vols., Chicago, 1927, 1929.
9. Colebrooke, H. T.; *Algebra, with Arithmetic and Mensuration from the Sanscrit of Brahmagupta and Bhāscara*; London, 1817.
10. Eisenlohr, A.; "Ahmes Papyrus"; (c. 1550 B.C.)
11. Friedlein, G.; *Die Zahlzeichen und das elementare Rechnen der Griechen und Römer*; Erlangen, 1869, p. 8.
12. Gow, James; *A Short History of Greek Mathematics*; Cambridge, 1884.
13. Haskins, Charles H.; *Studies in Histories of Medieval Sciences*; Cambridge, 1924.

14. Heath, Sir Thomas; *A History of Greek Mathematics*; Oxford, 1921.
15. Hill, G. F.; *Development of Arabic Numerals in Europe*; Oxford, 1915.
16. Hilprecht, H. V.; *Mathematical, Metrological, and Chronological Tablets from the Temple Library of Nippur*; Philadelphia, 1906.
17. Karpinski, L. C.; *An Exhibition of Early Textbooks on College Mathematics from the Collection in the University Library*; Ann Arbor, 1935.
18. ———; *History of Arithmetic*; Chicago, New York, 1925.
19. ———; *Robert of Chester's Latin Translation of the Algebra of Al-Khowarizmi*; New York, 1915.
20. Kaye, G. R.; *Indian Mathematicians*; Calcutta, 1915.
21. Miller, G. A.; *Historical Introduction to Mathematical Literature*; New York, 1916.
22. Peet, T. Eric; *The Rhind Mathematical Papyrus*; London, 1923.
23. PIHAN, A. P.; *Exposé des signes de numération*; Paris, 1860.
24. Plimpton, George A.; *History of Elementary Mathematics in the Plimpton Library*.
25. Rangacarya, M.; *Ganita-Sara-Sangraha of Mahaviracarya*; Madras, 1912.
26. Sanford, Vera; *Short History of Mathematics*; Boston, 1930.
27. Simons, Lao G.; *The Introduction of Algebra into American Schools in the Eighteenth Century*; Washington, 1924.
28. Smith & Ginsburg; *Numbers and Numerals*; New York, 1937.
29. Smith & Karpinski; *The Hindu-Arabic Numerals*; Boston, 1911.
30. Smith, David Eugene; *History of Mathematics*; Boston, 1923–25. Vol. I—General Survey of Elementary Mathematics. Vol. II—Special Topics of Elementary Mathematics.
31. Smith, David Eugene; *The Invention of the Decimal Fraction*; Teachers College Bulletin, First Series, No. 5.
32. ———; *Number Stories of Long Ago*; Boston, 1919.
33. ———; *Rara Arithmetica*; Boston, 1908.
34. ———; *Addenda to Rara Arithmetica*; Boston, 1939.
35. ———; *Source Book in Mathematics*; New York, 1929.
36. Steele, R.; *The Earliest Arithmetics in English*; Oxford, 1923.
37. Thomas-Stanford, Charles; *Early Editions of Euclid's Elements*; London, 1926.

5. SUGGESTED FACSIMILES

The following list of facsimiles is arranged chronologically, giving the author's name, title of book, place of publication, date of publication, reasons for inclusion, a few references, and a list of the best sources where facsimiles of the proper kind may be found.

Part I. Before 1000

Section A. Babylonian Mathematics.

Hilprecht Tablets—c. 2150 B.C. Arithmetic on clay cylinders; base 60 fractions. Facs: (1) Smith H. I., p. 40. (2) Hilprecht.
 Summarian Numerals. Cuniform numbers. Facs: (1) Smith & Ginsburg, Numbers & Numerals. (2) Menninger.

Section B. Egyptian Mathematics.

Bills, Accounts, and Tax-Lists. 2160–1788 B.C. Oldest Egyptian Mathematics. Facs: Originals in London and Berlin.
 Rhind Papyrus—Ahmes, 1825 B.C. Handbook of Arithmetic. Facs: (1) Complete Edition by British Museum. (2) Complete Edition by Open

- Court Publishing Co. (3) Smith, *Number Stories*, p. 21. (4) Smith, *History I*, p. 48. (5) Cajori, *Notations I*, p. 230.
- Temple of Der al-Bahri (Inscriptions)—1500 B.C. Reckoning with Numbers. Facs: Golenisheff.
- Tomb of Rekmire at Thebes—1500 B.C. Tax List of Upper Egypt.
- Rollins Papyrus—1350 B.C. Large Numbers appearing in Egyptian.
- Harris Papyrus—1167 B.C. Best Example of Practical Egyptian Accounts
- Michigan Mathematical Papyrus #621. Table of Eighths. Facs: Karpinski, in *Isis*.
- Petrie Papyri—Use of $\sqrt{\quad}$ for square-root. Facs: (1) Griffith Plate VIII. (2) Schack-Schackenburg, H.: *Zeitschrift für ägyptische Sprache und Altertumskunde*; Vol. XXXVIII (1900), p. 136; Plate IV; Vol. XL, p. 65.
- Egyptian Numerals. Facs: (1) From Cairo; Smith & Ginsburg, p. 11. (2) From Luxor; Smith, N. S., p. 17.

Section C. Greek Mathematics.

- Thales—624–547 B.C. Began Geometry; established Mathematics as a deductive science.
- Pythagorus—c. 540 B.C. Number Philosophy.
- Commercial Mathematics—418–415 B.C. Accounts of disbursements of the Athenian State. Facs: Brown, R., p. 26.
- Euclid—c. 300 B.C. Collected all material on Geometry in his "Elements." Facs: (1) c. 1260—Campanus Manuscript. Smith, *Rara*, Plate IV; Smith, *History I*, p. 219. (2) c. 1294—Prop 28 (Book IX) et. seq. on Theory of Numbers; S. *Rara* Plate V; Smith *History I*, p. 104. (3) 1350—Tabit Jbn Qorra Translation (Pythagorean Theorem); Smith, *History I*, p. 173. (4) 1482—Venice, pub. by Ratdolt. First printed edition; Smith, *History I*, p. 250; Thomas-Stanford. (5) 1505—Venice Ed. shows Fundamental Definitions; Thomas-Stanford. (6) 1509—Venice Ed. shows Prop. I–III; Thomas-Stanford. (7) 1570—Billingsley (or Dee) Translation. First English ed. Vertical Angles; Smith, *History I*, p. 323. (8) 1603—Ricci's Chinese Translation, Prop. I, Book I; Smith, *History I*, p. 305. (9) 1698—Samuel Reyher's Ed. (Kiel) First use of \angle for right angle.
- Archimedes—c. 225 B.C. "The Method" contains Quadrature of curvilinear plane figures and surfaces; computed π .
- Apollonius of Perga—c. 225 B.C. Collected material on Conics.
- Computation—c. 0. Wax Tablet showing Greek Logistic. Facs: Smith, *History I*, pl. 58.
- Nicomachus—c. 100. In "Introductionis Arithmeticae Libro duo." Collected material on Arithmetic.
- Ptolemy—c. 140–160. In "Almagest" (or "Syntaxis") collected material on Astronomy.
- Heron of Alexandria—?c. 200. "Metrica" is an encyclopedia and popular treatment on mathematical and physical subjects.
- Pappus of Alexandria—c. 300 A.D. *Synagoge* (or collection) was a guide or handbook to Greek Mathematics.
- Diaphantus of Alexandria—c. 275. Wrote on indeterminate Analysis. Facs: 14C Man.-Arithmetica; Smith, *History II*, p. 423.

Section D. Indian Mathematics.

- Anon.—c. 300–400. *Sūrya Siddhānta*; an early Indian Astronomy.
- Āryabhaṭa—c. 400. Wrote "Āryabhaṭāya" or "Āryabhaṭiṃ" on square root, arithmetic series, quadratic equations, and indeterminate linear equations.

- Varāhamihira—c. 505. Wrote "Pānca Siddhantika"; most celebrated writer on Astronomy in Early India.
- Brahmagupta—c. 628. Wrote "Brahmasiddhānta" about Arithmetic (Integers and fractions, progressions, Rule of Three, simple interest, and mensuration) and Algebra (applied to Astronomy, and indeterminate equation).
- Mahāvīra—c. 850. Wrote "Ganita-Sāra-Sangraha" on Arithmetic (e.g. inert divisor and multiply) and areas. Best Hindu contribution before Bhāskara.
- Bakhshālī—c. 8–10 C. Manuscript of doubtful Indian origin on Arithmetic and Algebra. Facs: Smith, History I, p. 165.
- Sridhara—c. 1025. Wrote "Triśatika" on Numeration, Measures, Rules, and Problems. Facs: (1) Smith, History I, p. 275. (2) Kaye, Indian Mathematics.
- Bhāskara—c. 1150. Wrote "Lilāvati" on Arithmetic and Mensuration: Notation, Operation, Rule of Three, Commercial Rules, Permutations, a little Algebra. Facs: (1) 1587: Fyzi's Translation, Smith, History I, p. 279 (Problem). (2) 1600: Manuscript. Smith, History I, p. 277 (Trapezoid Computation). (3) 1832: First edition printed in sanscrit. Smith, History I, p. 278 (Triangle solution).

Section E. Chinese Mathematics.

- Anon.—?2300–300 B.C. Shu-King, a Canon of History, tells a story of Astronomers foretelling an eclipse.
- Wōn-wang (?)—?1182–1135 B.C. Wrote "I-King" on Permutations.
- Anon.—c. 1105 B.C. Chōu-peī Suan-king is the Oldest real work on Mathematics in Chinese. Contains a figure for the Pythagorean Theorem.
- Ch'ang-Ts'ang—1105–2700 B.C. Wrote "K'iu-Ch'ang Suan-Shu" an Arithmetic in nine sections; one of the oldest but not very accurate.

Section F. Persian Mathematics.

- Mohammed ibn Mūsā al-Khoroārizimi, Abū 'Abdallāh—c. 825. Wrote "Al-jabr w'al muqābalsh" using Hindu numerals to solve equations. Facs: (1) c. 1120—Adelaid of Bath's Edition. (2) 1456—Latin Manuscript. First page; Smith, Rara, p. 455; Smith, History II, p. 383.
- Al-Karkhī—c. 1000. In "Fakhī" wrote of 1st and 2nd degree equations and indeterminate analysis.

Part II. 1000–1500

Anicius Manilius Severinus Boethius—c. 500, Rome, Italy.

- Works: (1) Boethii de institutione arithmetica libro duo
 (2) Boethii quae fertur geometria
 (3) Boethii di institutionae musicae libri quinque

Wrote textbooks for Monastic Schools, copying the Arithmetic from Nicomachus, the Geometry from Euclid, and also Music.

- Facs: (1) of (1) (Man. c. 1294) Figurate numbers; Smith, Rara; Sanford, p. 331; Smith, History I, p. 181.
 (2) of (1) (Man. c. 1300) End showing proportions; Smith, Rara
 (3) Arithmetica, Augsburg, 1488—First printed edition; Multiplication Table; Sarton, Osiris (Vol. 5) 1938; Smith, Rara, p. 26.

Bede the Venerable—c. 726, England.

Works: De temporum ratione.

First European Scholar to write on Mathematics after Roman Period.

Wrote on Finger Notation, Calendar, and Theory of Numbers.
Alwin of York—c. 780, England.

Works: Propositiones ad acuendos jervenas.

Tried to relieve education of its drudgery by compiling a set of puzzles greatly drawn upon by textbook writers.

Gerbert (Pope Sylvester II)—c. 999, France.

Works: (1) *Regulae de numerorum abaci rationibus*; *Scholium ad Boethii arithmeticum*.

Great Pope who first showed interest in Mathematics after the dark ages. First European scholar known to have used the Hindu-Arabic numerals.

Leonardo Fibonacci (Leonardo of Pisa)—1202, Italy.

Works: (1) *Liber Abaci* (1202).

(2) *Tre Sonitti inediti di Leonardo Pisarro*; Florence, 1854.

Greatest and most productive mathematician of the Middle Ages; wrote on Arithmetic and Algebra, expounding the use of the Hindu-Arabic numbers.

Anon. (Man.)—1300

Work: *The Crafte of Nombrynge*

Manuscript showing seven fundamental operations; traces of counter-reckoning; and satisfactory definition of division.

Johannes de Sacrobosco—c. 1442, Germany.

Work: (Manuscript)

Early use of Hindu-Arabic Numerals.

Johann Müller (Regiomontanus)—1464, Germany.

Work: *De triangulis omnim odis*

Founder of Trigonometry in its Modern Form.

Facs: Letter (c. 1463) solving equation; Smith, Hist. II, p. 429.

Anon.—1478, Italy.

Work: *Treviso Arithmetic*, Treviso, Italy

First Printed Arithmetic.

Facs: (1) First page; Smith, Isis

(2) Mul. & Galley Division; Smith, Rara, p. 6

(3) Four types of Multiplication; Smith, Rara, p. 5; Smith, Isis; Smith & Ginsburg, Numbers & Numerals, p. 30; Cajori, Notations I, p. 99.

(4) Solution of Problem: (Time, rate, and distance) Cajori, Notations I, p. 98.

Johann Widman—1489, Germany (Pforzheim)

Work: *Behēde vud hubsche Rechnung auf allen kauffmanschafft*. First use of + and - signs, as excess and deficiency and also for algebric uses.

Facs: (1) Multiplication table; Smith & Ginsburg, Numbers & Numerals, p. 30.

(2) Multiplication table, (1500 edition); Smith, Rara, p. 37.

(3) + and - signs (1526 ed.) Cajori, Notations I, p. 130.

Filippo Calandri—1491, Florence, Italy.

Work: *Pictagorus arithmetrice introductor*.

First printed explanation of long division and first problem in Algebra books to be illustrated with pictures.

Facs: (1) First printed explanation of long division; Smith, History II, p. 142; Smith & Ginsburg, Numbers and Numerals, p. 31; Smith, Number Stories, p. 78.

(2) Division & Multiplication of Whole Numbers, division of fractions; Smith, Rara, p. 47.

(3) First illustrated problem: Smith, Rara, p. 48, 49; Smith, History I, p. 255.

Francesco Pellos (or Pellizzati)—1492, Turin, Italy.

Work: Pellos Arithmetic.

First decimal point in print.

Facs: (1) Division; Smith, *Rara*, p. 52.

(2) First decimal point in print; Sanford, p. 110.

Luca Pacioli—1494, Venice, Italy.

Work: *Summa de Arithmetica*.

Mainly Algebra, Business Arithmetic, Euclid, and Double-entry bookkeeping compiled from Euclid, Ptolemy, Boethius, Fibonacci, Jordanus, etc.; but very full of errors.

Facs: (1) Title-page; Sartor, *Osiris* (Vol. 5) 1938; Smith, *History I*, p. 253.

(2) Finger symbolism; Smith, *Rara*, p. 57.

Part III. 1500-1600

Anon.—16th C., Venice, Italy.

Work: *Opus Arithmetica D. Honorati veneti monachj coenobij S. Laurétij*.

Example of Galley Division.

Facs: (1) Smith, *History II*, p. 138.

Giel Vander Hoecke—1514, Antwerp, Holland.

Work: *Een Sonderlinghe*.

First use of + and - in Algebra in Holland (see Schreiber).

Facs: (1) First use of + and - in Algebraic Expressions; Smith, *History II*, p. 399.

(2) 1537 ed. Early use of + and - signs; Smith, *History II*, p. 401.

Heinrich Schreiber (Grammateus)—1518, Nurnberg, Germany.

Work: *Ayn new Kunstlich Buech*.

First use of + and - in Algebra in Germany (see Vander Hoecke).

Facs: (1) Equations; Cajori, *Notations I*, p. 130.

(2) First use of + and - signs for Algebra; (1935 ed. II) Cajori, *Notations I*, p. 131.

Cuthbert Tonstall—1522, London, England.

Work: *De Arte soppotandi libri quattvor Cotheberti Tonstalli*.

The first mathematical book published in England; but very dull.

Adam Riese—1522, Erfurt, Germany.

Work: *Rechnong auff der Linien und Federn*.

Stressed written computation over counter computation.

Facs: (1) Table of square roots without decimal point; Smith, *History II*, p. 237; Sanford, p. 108.

(2) See Smith; *Decimal Fractions*.

Petrus Apianus—1527, Ingolstadt, Germany.

Work: *Arithmetic*.

First appearance of Pascal's Triangle in print, long before Pascal's time.

Facs: Pascal's Triangle; Smith, *Rara*, p. 156, Sanford, p. 178.

Christoff Rudolf—1525, Germany.

Work: (1) *Die Coss* (?)—1525.

(2) *Exempel-Büchlin*—1530 and 1540.

"Die Coss" revised by Stifel was a very influential Arithmetic; it gave the rules for multiplication of signs. "Exempel-Büchlin" shows early decimal fractions using a bar for decimal points.

Facs: (1) Compound interest table: Smith, *History II*, p. 241, Sanford, p. 109.

(2) See Smith, *Decimal Fractions*.

Robert Record—1540, London, England.

Works: (1) *The Ground of Artes*—1540.

(2) *Whetstone of Witte*—1557.

The *Ground of Artes* was not the first Arithmetic in English, but the earliest of lasting influence; it was a commercial arithmetic. *Whetstone of Witte* contains the first use of the = sign.

Facs: (1) of (1) *Counter Reckoning*—Smith & Ginsburg, *Numbers & Numerals*, p. 28; Smith, *Number Stories*, p. 58; Smith, *Rara*, p. 215.

(2) of (1) Use of \times to extend multiplication table above 5×5 .

(3) of (2) *Title Page*; Smith, *History I*, p. 319.

(4) of (2) First use of = sign; Sanford, p. 154; Cajori, *Notations I*, p. 165; Smith, *Rara*, p. 288.

(5) of (2) *Fractions*; Cajori, *Notations I*, p. 166.

Copernicus—1543, Cracow, Poland.

Work: *De revolutionibus orbium coelestium* (Nurnberg).

Heliocentric theory of Astronomy.

Michael Stifel—1545, Nürnberg, Germany.

Work: *Deutsche Arithmetica*.

Stifel made the +, - signs popular and invented negative exponents.

Facs: +, - signs, Smith, *Rara*, p. 234.

Hieronymo Cardan—1545, Milan, Italy.

Work: *Ars Magna*, Nürnberg.

The *Ars Magna* recognized negative roots and gave simple rules for negative numbers; there is a solution of the cubic (due to Tortaglia) and the biquadratic (due to Ferrari).

Facs: (1) *Roots & Expressions*; Cajori, *Notations I*, p. 119.

(2) *Solution of the Cubic*; Smith, *History II*, p. 462, 463.

Trans: (1) *Treatment of Imag. roots*; Smith, *Source Book*, p. 201.

(2) *Solution of the Cubic*; ditto, p. 203.

(3) *Solution of the Biquadratic*; ditto, p. 207.

Francesco Ghaligai—1552, Florence, Italy.

Work: *Practica d'arithmetica*.

Typical textbook.

Facs: *Designation of Powers*; Cajori, *Notations I*, p. 114.

Juan Diez—1556, Mexico City, Mexico.

Work: *Summario cõpẽdroso delas quẽtas*.

First book on mathematics published in the New World.

Facs: *Congruent and Congruous numbers*; Smith, *Hist. I*, p. 356.

Jakõb Kobal—1514, Oppenheim, Germany.

Work: *Rechnenbiechlin*.

Typical *Rechnenbuch*; not very widespread in use.

Facs: *Fractions* (1564 ed.); Smith & Ginsburg, *Numbers and Numerals*, p. 36.

Rafaele Bombelli—1572, Venice, Italy.

Work: *L'Algebra*.

A splendid *Algebra* which points out the reality of roots of an irreducible cubic, even when expressed as imaginaries.

Facs: *Use of L for aggregation*; Cajori, *Notations I*, p. 125.

Simon Stevin—1585, Leyden, Holland.

Work: *La Thiende*

First reduction of fractions to work with whole numbers by complete explanation of decimal fractions.

Facs: (1) *Pages illustrating decimals*: Sanford, p. 113; Cajori, *Notations I*, p. 155; Smith, *History II*, p. 243; Smith & Ginsburg, *Numbers & Numerals*, p. 37.

- (2) *Les Oeuvre Mathematiques de Simon Stevin* (ed. A. Girard, Leyden, 1634), p. 209.

- (3) "La Thiende" de Simon Stevin, printed by the Societé des Bibliophilie Arversoïs, Antwerp, 1924.

Trans: Smith, Source Book, p. 20.

Franciscus Vieta—1591, Tours, France.

Work: (1) *In Artem analyticam isagoge*.

Introduced a systematic use of letters for general quantities, used general numbers as coefficients in equations, developed method of reduction and successive approximation in the theory of equations, and developed π as an infinite product.

Facs: Letters for general quantities, and general numbers as coefficients in equations; Cajori, Notations II, p. 4.

Thomas Masterson—1592, London, England.

Work: *First Books of Arithmetick*.

Early Arithmetic.

Facs: Notation for Powers; Smith, Rara, p. 403.

Bartholemäns Pitiscus—1595, Frankfort, Germany.

Work: *Trigonometriae sive de dimensione triangularum libri quinque*.

First satisfactory book on Trigonometry, and the first to bear that title.

Trans: Smith, Source Book, p. 434.

Part IV. 1600–1800

Christophorus Clavius—1608, Italy.

Work: *Algebra Christophori Clavii Bambergensis e Societate Iesv*.

Introduced the German notation into Italy; especially the + and – signs.

Facs: Round Parenthesis to show aggregation; Cajori, Notations I p. 153.

John Napier—1614, Edinburgh, Scotland.

Work: *Mirifici Logarithmorum canonis descriptio*.

Inventor of Logarithms.

Trans: Smith, Source Book, p. 149.

Paz—1623.

Work: *Arithmetica*.

Earliest Arithmetic published in America.

Facs: Cajori, in *Isis IX*.

William Oughtred—1631, London, England.

Work: *Clavis Mathematicae*.

A great inventor and popularizer of symbols; e.g. \times for multiplication, the \pm sign, \angle for angle, and many other algebraic and geometric symbols.

Thomas Harriot—1631, London, England.

Work: *Artis analyticae proxis*.

First use of $<$ and $>$ for "less than" and "greater than."

Pierre Hérigone—1634, Paris, France.

Work: *Cursus mathematicus*.

Clever symbolist; used \perp for perpendicular, and the interesting signs now extinct: $2/2$ for $=$, $3/2$ for $>$, $2/3$ for $<$.

René Descartes—1637, Paris, France.

Work: *La Géométrie*.

Founded analytic Geometry; introduced the modern notations for exponents; used x , y , z for unknowns.

Facs: (1) Page #1; Sanford, p. 297.

(2) Complete Edition; Smith & Latham.

Trans: Smith, Source Book, p. 397.

Blaise Pascal—1640, Paris, France.

Work: *Essayer pour les Coniques*.

Wrote his essay on the beautiful theorem on Conics when 16 years old.

Facs: (1) Clarke, F. M. in *Is8s*, Vol. X.

(2) Sanford, p. 286.

Trans: Smith, Source Book, p. 326.

Atanasius Reaton—1649.

Work: *Arte Manor de Arismetica*.

Earliest known American Arithmetic.

Facs: Karpinski, *Isis IX*.

John Wallis—1655, England.

Work: (1) *Arithmetica Infinitorum*.

(2) *De Algebra Tractatus, Historicus and Practicus* (with Newton).

Gave first explanation of general exponents, and explained Newton's work on the Binomial Theorem for negative and fractional exponents.

Trans: (1) of (1) Smith, Source Book, p. 217.

(2) of (2) Smith, Source Book, p. 219.

Johann Heinriche Ralm—1659, Zurich, Germany.

Work: *Teutoche Algebra*.

Introduced the \div sign for division and \therefore for "therefore." Wrote *Algebra* in 3 columns similar to geometry proofs.

Facs: Cajori, *Notations I*, p. 213.

John Kersey—1673, London, England.

Work: *Algebra*.

First use of \parallel for parallel lines.

Isaac Newton—1676, London, England.

Works: (1) *Letters to Leibnitz* (1676).

(2) *Philosophia Naturlis Principia Mathematica* (1687).

(3) *Quadratura Curvarum* (1794).

(4) *Method of Fluxions & Infinite Series* (1736).

Extended the binomial theorem to general exponents, laid a foundation for the calculus with Fluxions, and tied the universe into the neat bundle of "Newton's Laws."

Trans: (1) of (1) Smith, Source Book, p. 224.

(2) of (3) Smith, Source Book, p. 614.

Gottfried Wilhelm Leibnitz—1684, Hanover, Germany.

Work: *Nova methodus pro maximis et minimis*.

Understood determinants. Developed the calculus with a splendid notation independent of Newton.

Trans: (1) Smith, Source Book, p. 620.

(2) Smith, Source Book, p. 267 (*Determinants*).

Isaac Greenwood—1729, Boston, U. S. A.

Work: *Arithmetick Vulgar and Decimal*.

Earliest known American Arithmetic describing decimals.

Facs: Karpinski, *History of Arithmetic*.

William Jones—1706, London, England.

Work: *Synopsis Palmariorum Mathescos*.

First use of π as the ratio of circumference to diameter.

Facs: Cajori, *Notations II*, p. 9.

Trans: Smith, Source Book, p. 346.

Adrien-Marie, Legendre—1794, Paris, France.

Work: *Élément de géométrie*.

Great modern rival of Euclid as a textbook writer of elementary geometry.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem, sent to the Editor should have the author's name introducing the problem or solution as on the following pages.

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

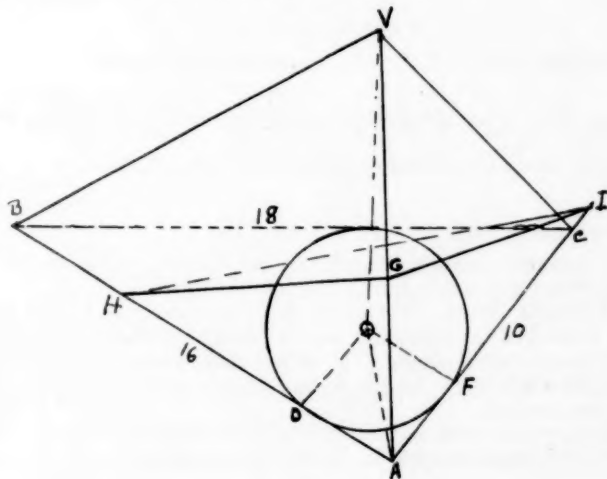
1. Drawings in India ink should be on a separate page from the solution.
2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.
3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

In the solution offered to 1738, April 1942 issue, it has been pointed out that the conclusion following (12) is not valid. Anyone having a complete solution is requested to offer it at once.

EDITOR

1783. Proposed by Harry Guinner, Jackson, Miss.



A triangular pyramid $V-ABC$ has dimensions: $AC=10$; $AB=16$; $BC=18$; altitude $VO=20$. The vertex, V , is in a line perpendicular to the base at the center of the inscribed circle of the base. Find the angle between the faces VAB and VAC .

Solution by W. R. Smith, Sultons Bay, Mich.

By trigonometry, angle $A=84^{\circ}16'$, $B=33^{\circ}34'$, also from triangles ODA and OFA , $AD=4$, $BD=12$, $AO=5.39$, $BO=12.53$. In right triangles VOA and VOB , $VA=20.71$ and $BV=23.6$. Hence solving triangle VAB , angle $VAB=78^{\circ}52'$.

Let G be a point on VA , any given distance from A . Draw GH in the plane VAB , perpendicular to VA , intersecting AB or its continuation at H . Draw GI in plane VAC , perpendicular to VA , intersecting AC or its continuation at I .

Let $GA=4$.

In right triangle AGH , $GA=4$, $GAB(VAB)=78^{\circ}52'$. Hence $GH=20.33$, $AH=20.72$.

Since O is the center of inscribed circle, triangles ODA and OFA are equal and pyramids $V-ODA$ and $V-OFA$ are equal. Hence angles $GAB(VAB)$ and $GAC(VAC)$ are equal and GI equals GH and AI equals AH .

In triangle AHI , $AH=20.72$, $AI=20.72$, angle $HAI=84^{\circ}16'$. Hence $HI=27.80$.

In triangle HGI , $GH=20.33$, $GI=20.33$, $HI=27.80$. Hence angle HGI equals $86^{\circ}16'$, the angle between planes VAB and VAC .

Solutions were also offered by Helen M. Scott, Baltimore, Md. and the proposer.

1784. *Proposed by Paul D. Thomas, Durant, Okla.*

Show that

$$\sum_{n=0}^{\infty} \frac{1}{n^2+5n+6} = \frac{1}{2}.$$

Solution by David Rappaport, Chicago, Ill.

$$\frac{1}{n^2+5n+6} = \frac{1}{n+2} - \frac{1}{n+3}.$$

Substituting $n=0, 1, 2, 3, \dots$ we get an infinite series

$$\sum_{n=0}^{\infty} \frac{1}{n^2+5n+6} = \frac{1}{2} - \frac{1}{3} + \frac{1}{3} - \frac{1}{4} + \frac{1}{4} - \frac{1}{5} + \dots = \lim_{n \rightarrow \infty} \left(\frac{1}{2} - \frac{1}{n+2} \right) = \frac{1}{2}.$$

Solutions were also offered by Aaron Buchman, Buffalo, N. Y. and the proposer.

1785. *Proposed by Cecil B. Read, Wichita, Kan.*

In any triangle obtain a formula for the distance between the centers of the inscribed and circumscribed circles.

Mrs. Edith M. Warne, Rochester, N. Y. reminds the Editor that this problem is worked in Altshiller-Court's College Geometry, page 108. The solution there is very simple. The required distance, d , is given by the equation, $d^2=R(R-2r)$, where R and r are radii of circumcircle and incircle, respectively.

Solutions, much more complicated were offered in geometry, analytic geometry, and trigonometry by Jamia Smith, Syracuse, N. Y.; Samuel

Nash, Lewiston, Maine; Verna Seeley, Oaks Corners, N. Y.; and Walter R. Warne, Rochester, N. Y.

1786. *Proposed by Waller M. Sackett, Jr.*

Solve for all values of x in circular radians the equation:

$$\cos^2 x + 3.$$

Solution by the proposer

$$\cos^2 x + 3 = 0$$

$$\cos x = i\sqrt{3}.$$

(One may substitute $1 - \sin^2 x$ for $\cos^2 x$ but the problem is not simplified.)

Since

$$\cos \theta = \frac{e^{i\theta} + e^{-i\theta}}{2},$$

then

$$\frac{e^{ix} + e^{-ix}}{2} = i\sqrt{3}$$

$$e^{ix} + \frac{1}{e^{ix}} = 2i\sqrt{3}$$

$$e^{2ix} - e^{ix} \cdot 2i\sqrt{3} + 1 = 0$$

$$e^{ix} = \frac{2i\sqrt{3} \pm \sqrt{-12-4}}{2}$$

$$= i\sqrt{3} \pm i\sqrt{4}$$

$$= i(\sqrt{3} \pm 2)$$

$$ix = \log_e i + \log (\sqrt{3} \pm 2)$$

$$x = -i \log i - i \log (\sqrt{3} \pm 2). \quad (1)$$

$$\left[e^{i\pi(2n+1)} = -1, \text{ hence } e^{i\pi(2n+1)/2} = i. \text{ Also, } e^{-i\pi(2n+1)/2} = i, \frac{-\pi(2n+1)}{2} = i \log i \right].$$

By substitution in (1)

$$x = \frac{\pi(2n+1)}{2} - i \log (\sqrt{3} \pm 2).$$

1787. *Proposed by Waller M. Sackett, Jr., Evanston, Ill.*

In the identity $(a+ib)^{c+id} = x+iy$, find x and y in terms of a, b, c, d .

Solution by Aaron Buchman, Buffalo, N. Y.

Let a, b, c, d , be real. Let

$$r = (a^2 + b^2)^{1/2}, \theta = \cos^{-1} \left[\frac{a}{(a^2 + b^2)^{1/2}} \right]. \quad (1)$$

Thus r and θ are both real. Using the relation (1) and the well known relation, $e^{x+iy} = e^x(\cos y + i \sin y)$,

$$(a+ib)^{c+id} = [r(\cos \theta + i \sin \theta)]^{c+id}$$

$$= r^c(\cos c\theta + i \sin c\theta) \cdot r^{id}(\cos id\theta + i \sin id\theta)$$

$$= r^c(\cos c\theta + i \sin c\theta) \cdot e^{id \log r} \cdot e^{-d\theta}$$

$$= r^c(\cos c\theta + i \sin c\theta)(\cos [d \log r] + i \sin [d \log r]) \cdot e^{-d\theta}$$

$$= re^{-d\theta} [\cos (c\theta + d \log r) + i \sin (c\theta + d \log r)]. \quad (2)$$

Since (2) is the given expression separated into its real and imaginary parts, then

$$x = re^{-d\theta} \cos (c\theta + d \log r) \quad (3)$$

and

$$y = re^{-d\theta} \sin (c\theta + d \log r). \quad (4)$$

Using (1) to replace r and θ in (3) and (4), the values of x and y in terms of a, b, c, d result.

Note: The principal value of $\log r$ which is real is to be taken.

Solutions were also offered by Walter R. Warne, Rochester, N. Y. and the proposer.

1788. *Proposed by Owen Saunders, Gainesville, Texas.*

Three equal circles with radius, x , are tangent each to the other two. The area enclosed by the circles (minor arcs) is one acre. Find the diameter of a circle.

Solution by J. E. Russell, Glen Ellyn, Ill.

The area of the equilateral triangle each side x , formed by the lines of centers, is equal to $x^2\sqrt{3}$. The area of the three sectors of the three circles

is equal to $\frac{\pi x^2}{2}$. The area enclosed by the circles is equal to:

$$x^2\sqrt{3} - \frac{\pi x^2}{2} = \text{one acre} = 43,560 \text{ sq. ft.}$$

$$x^2 = \frac{43,560}{\sqrt{3} - \pi/2} = 270,056$$

$$x = 519.6 \text{ feet.}$$

$$\text{Diameter} = 2x = 1039 \text{ feet.}$$

Solutions were offered also by David Rappaport, Chicago, Ill.; Mrs. Edith M. Warne, Rochester, N. Y.; Mary Gable, Petersburg, Va.; I. N. Warner, Platteville, Wis.; Martyn Summerbell, Lewiston, Me.; Helen M. Scott, Baltimore, Md.; Walter R. Warne, Rochester, N. Y.; and W. R. Smith, Suttons Bay, Mich.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

EDITOR'S NOTE TO HIGH SCHOOL STUDENTS:—It is the hope of the Editor that this year will bring more contributors to this department. Please send problems, solutions, comments.

1784. Edgar Cooke, Toronto, Canada; K. A. G. Miller, Toronto, Canada.

1788. K. A. G. Miller, Toronto, Canada; David Pilkington, Toronto, Canada; Winfred Lemke, Sheboygan, Wis.

PROBLEMS FOR SOLUTION

1801. *Proposed by Walter R. Warne, Rochester, N. Y.*

If ABC is a triangle, prove the identity:

$$\frac{\cot A + \cot B}{\tan A + \tan B} + \frac{\cot B + \cot C}{\tan B + \tan C} + \frac{\cot A + \cot C}{\tan A + \tan C} = 1.$$

1802. *Proposed by Ezekial W. Mundy, Syracuse, N. Y.*

The sum of two odd squares can not be a square.

1803. *Proposed by Ira D. Conley, Hayts Corners, N. Y.*

Find by trigonometry and calculus

$$\lim_{x \rightarrow 0} \frac{\sin(\tan x) - \tan(\sin x)}{x^7}.$$

1804. *Proposed by Norman Anning, University of Michigan.*

Given: $a^2 + b^2 = 7$ and $a^3 + b^3 = 10$, find $(a + b)$.

1805. *Proposed by Julius Brandstatter, Los Angeles, Calif.*

Find the envelope of the family of circles whose diameters are double the ordinates of the ellipse

$$b^2x^2 + a^2y^2 = a^2b^2.$$

1806. *Proposed by George W. Rolison, Oshkosh, Wis.*

Prove that $\tan 3x \cot x$ has no values between 3 and $1/3$.

SCIENCE QUESTIONS

January, 1943

Conducted by Franklin T. Jones,

10109 Wilbur Avenue, SE., Cleveland, Ohio

Contributions are desired from teachers, pupils, classes and general readers. Send examination papers from any source whatsoever.

It is natural that questions connected with the War Effort will be especially appreciated.

Questions on any part of the field of science; questions having to do with the pedagogy of science; new applications of old ideas; present variations of perhaps ancient questions; anything that appeals to the reader, or might appeal to other readers—all are wanted.

What interests you will most likely interest others also.

We will endeavor to obtain answers to all reasonable questions. It is always valuable to get questions whether we can get the answers or not.

Contributors to SCIENCE QUESTIONS are accepted into the GQRA (Guild of Question Raisers and Answerers).

Classes and teachers are invited to join with others in this co-operative venture in science.

JOIN THE GQRA!

PISCICULTURE

986. Suggested by articles in *SCIENCE NEWS LETTER*, CLEVELAND PLAIN DEALER and others.

What is the science of pisciculture?

Webster says— (We say, "You look it up!")

John W. W. Sullivan, Sc.D., on editorial page of *Cleveland Plain Dealer* says—"Before the end of this war pisciculture, or fish farming, may be practiced on farm lands of low fertility throughout the country."

Think it over! Have a fish farm in that little creek behind the barn! Put a little dam across the stream and raise your own fish!

Do you know?—that about 60 years ago it was all the rage to do that very little thing and it worked fine until high water came along and washed about all the fish down stream. German carp was the favorite fish for planting because it could endure stagnant water and would eat grass. However, those carp traveled true to form and, when they had gotten into bigger waters like Lake Erie, they lost their appetite for grass and became voracious eaters of smaller and weaker fish. They gobbled up the small fry and spoiled future generations of bass, whitefish, pike, and perch. The carp got so big and fat that they lost their original flavor, which perhaps was not so bad, and tasted—just like a big German carp! They were destructive of everything they met and it became a big problem as to how to destroy them fast enough so that useful things could grow again.

(This did not start out as an Aesop's Fable applying to modern conditions but just the same the comparison is not so bad.)

Science News Letter suggests, quoting from *U. S. Fish and Wildlife Service*, that "Fish on Friday may become carp on Monday, quillback on Tuesday, skate on Wednesday and alewife on Thursday." If they are all as good as carp, you will have a fine appetite for some bacon and eggs on Friday. However, you might keep right on and eat lawyer on Friday, mullet on Saturday and sucker on Sunday. (This is on the theory that you won't choke, even on the bones in mullet and sucker, if you can live through the ordeal of the first four days of the week.)

History teaches that we do not learn from the mistakes of our predecessors but instead read about them and repeat them. Perhaps you will engage in pisciculture too!

SCIENCE—POPULAR AND USEFUL

987. Suggested by *LIFE'S* publication of everyday experiments.

Quote from *Life*, Nov. 23, 1942, pp. 132-142.

"In 1941 enormous numbers of Americans were suddenly forced to begin fumbling with unfamiliar and complex scientific apparatus. To show a few simple physical and chemical laws by which airplanes, submarines, sound detectors, electroplaters and other complicated machines and processes operate, Kenneth Seezey, a Brooklyn, N. Y. photographer-writer, set up these lucid tabletop demonstrations. With a few props from the kitchen plus a doorbell battery anyone can have the fun of repeating them. To his friends and himself the parlor scientist can prove that the basic principles of science are easily understood and when clearly demonstrated are often just as startling as their more involved applications. To men who fly airplanes, man submarines or operate chemical plants, these experiments will prove that the complicated accomplishments of their machines are governed only by the extensions of simple principles."

Experiments illustrated—Streamline effect, Sound-wave principle, In-

compressibility of water, Molecular structure, Contraction of rubber, Synthesis, Electrolysis, How fire is extinguished.

(Incidentally one or more of these experiments may not be labelled with the scientific accuracy which we try to demand. F.T.J.)

To every tale there is a moral!

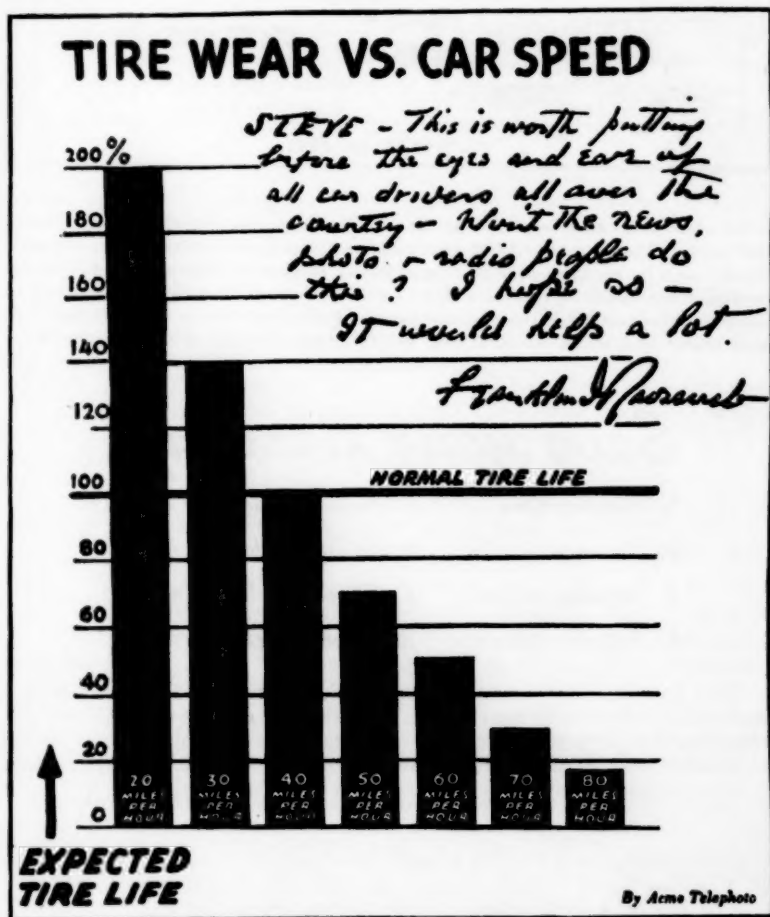
Right now the science and mathematics teachers of the country have everything coming their way. They are no longer the underdogs of the curriculum. Their product is useful, popular, applicable to daily life, not so hard that the average pupil can not get it, and so on.

What is the danger to science teaching?

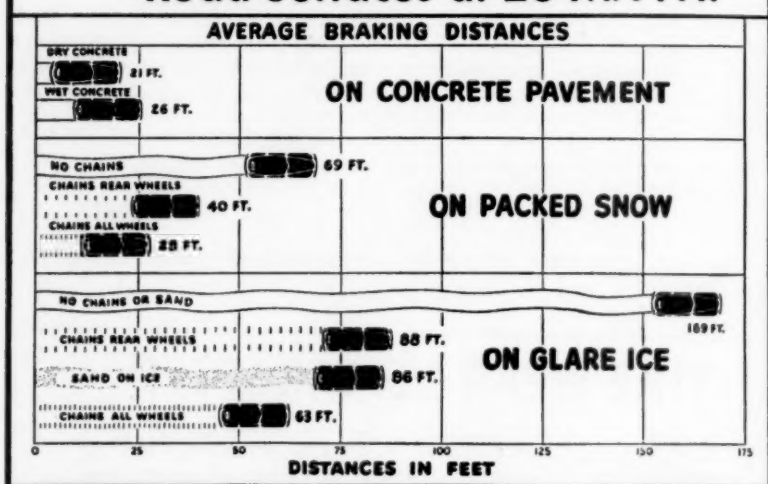
There are several. The over-ambitious teacher will try to make his subject too hard. Then he will fail too many, and he will lose the public sympathy which he now possesses.

SAVING TIRES BY REDUCED SPEEDS

989. Charts from THE OHIO MOTORIST.



Braking Distances on Various Road Surfaces at 20 M. P. H.



The above guide on average braking distances for automobiles according to condition of road surface is based on over 3,000 tests made on frozen Lake Cadillac, Mich., and snow covered roads by the Committee on Winter Driving Hazards in February, 1940. (Actual stopping distances are 22 feet more than each of the average braking distances shown in above chart because it takes the average motorist three-quarters of a second to react and apply brakes after seeing reason to stop, and this means 22 feet at 20 miles per hour.)

National Safety Council Chart

Save your tires by:-

1. Rotating tires
2. Re-capping tires
3. Inflating properly
4. Treating sidewalls
5. Repairing cuts and bruises
6. Driving under 35 M.P.H.
7. Checking wheel alignment
8. Removing glass, tacks, etc.

That you may have them in SCHOOL SCIENCE AND MATHEMATICS for convenient reference in your classes these three charts are published at this time. Once we were interested first in the saving of life, again in the saving of gasoline, now we are attacking the same problem for the saving of rubber.

Save Rubber! Drive Safely! Go Slowly! Be Patriotic!

GQRA members are asked to mail their pictures, formal or snapshot, to F. T. Jones, 10109 Wilbur Avenue, SE., Cleveland, Ohio.

A "Contributors' Scrapbook" is in process. Please respond.

TRAINING FOR YOUTH AND WAR WORKERS

988. *Read the two sets of experiments and discussions in SCIENCE NEWS LETTER for November 21, 1942, pp. 328-9.*

MACHINES—1. Terms related to the Study of Matter.

ELECTRICITY—1. Magnetism Explained; Many Uses.

(Written to conform with the pre-induction training outlines of the War Department.)

BOOKS AND PAMPHLETS RECEIVED

PRINCIPLES OF COLLEGE ALGEBRA, by Morris S. Knebelman, *Head of the Department of Mathematics, The State College of Washington*, and Tracy Y. Thomas, *Professor of Mathematics, University of California at Los Angeles*. Cloth. Pages x+380. 14.5×22 cm. 1942. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price \$2.50.

EXPERIMENTAL ELECTRONICS, by Ralph H. Müller, *Professor of Chemistry, New York University*; R. L. Garman, *Assistant Professor of Chemistry, New York University*; and M. E. Droz, *Assistant Professor of Chemistry, New York University*. Cloth. Pages xv+330. 14.5×22.5 cm. 1942. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price \$3.50.

PROCESS PRACTICE IN THE AIRCRAFT INDUSTRY, by Frank D. Klein, Jr., *Senior Metallurgist, Materials Control Branch, United States Army Air Forces*. Cloth. Pages xii+266. 15×23 cm. 1942. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price \$2.75.

ELEMENTARY METEOROLOGY, by Vernor C. Finch, *Professor of Geography, University of Wisconsin*; Glenn T. Trewartha, *Professor of Geography, University of Wisconsin*; M. H. Shearer, *Westport High School, Kansas City Missouri*; and Frederick L. Caudle, *Assistant Professor and Coordinator, Civilian Pilot Training University of Wisconsin, Extension Division, Official in Charge, Weather Bureau Airport Station, Madison*. Cloth. Pages x+301. 15×23 cm. 1942. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price \$1.76.

MATHEMATICS FOR MECHANICS, by William L. Schaaf, Ph.D., *Assistant Professor of Education, Brooklyn College*. Cloth. Pages x+298. 13.5×21 cm. 1942. Garden City Publishing Company, 14 W. 49th Street, New York, N. Y. Price \$2.00.

PREPARING FOR BUSINESS, by Charles W. Hamilton, B.C.S., B.S. in Ed., M.D., *Assistant in Secondary Education, New Jersey State Department of Public Instruction*; J. Francis Gallagher, B.S. in Ed., M.A., *Principal, Alexander Hamilton Junior High School, Elizabeth, New Jersey*; and Charles Fancher, LL.B., M. in Ed., *Teacher of Business Subjects, Elizabeth Public School, Elizabeth, New Jersey*. Cloth. Pages xii+493. 15×23 cm. 1942. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price \$1.60.

ESSENTIAL MATHEMATICS FOR SKILLED WORKERS, by Harry M. Keal, *Head of Mathematics Department, Cass Technical High School, Detroit*, and Clarence J. Leonard, *Head of Mathematics Department, Southeastern High School, Detroit*. Cloth. Pages vii+293. 12×18 cm. 1942. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price \$1.50.

FUNDAMENTALS OF RADIO, by Edward C. Jordon, *Instructor in Electrical Engineering, Ohio State University and Associate, Institute of Engineers*; Paul H. Nelson, *Assistant Professor of Electrical Engineering, The University of Connecticut*; William Carl Osterbrock, *Professor of Electrical Engineering, University of Cincinnati and Member of A.I.E.E. and I.R.E.*; Fred H. Pumphrey, *Professor of Electrical Engineering, Rutgers University*; Lynne C. Smeby, *Director of Engineering for the National Association of Broadcasters and Member of the Board of Editors of The Institute of Radio Engineers*. Cloth. Pages xiii+400. 15×23 cm. 1942. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price \$3.75.

LIFE SCIENCE, by George W. Hunter, Ph.D., *Lecturer in Methods of Education in Science, Claremont Colleges, Claremont, California*. Cloth. Pages xii+803. 16×23 cm. 1941. American Book Company, 360 N. Michigan Avenue, Chicago, Ill.

MODERN CHEMISTRY, by Charles E. Dull, *Head of Science Department, West Side High School, and Supervisor of Science for the Junior and Senior High Schools, Newark, New Jersey*. Cloth. Pages xi+604+xxiv. 15×23.5 cm. 1942. Henry Holt and Company, Inc., 257 Fourth Avenue, New York, N. Y. Price \$2.00.

EARTH'S ADVENTURES, by Carroll Lane Fenton. Cloth. 207 pages. 14.5×23 cm. 1942. The John Day Company, Inc., 2 W. 45th Street, New York, N. Y. Price \$3.00.

THE METHODOLOGY OF PIERRE DUHEM, by Armand Lowinger. Cloth. 184 pages. 13.5×22 cm. 1941. Columbia University Press, Morningside Heights, New York, N. Y. Price \$2.25.

HOW TO READ MILITARY MAPS, by Roderick Peattie, *Professor of Geography, Ohio State University*. Cloth. Pages v+74. 12×19 cm. 1942. George W. Stewart, Publisher, Inc., 67 W. 44th Street, New York, N. Y. Price \$1.50.

MERRIMAN'S STRENGTH OF MATERIALS, Revised by Edward K. Hankin, *Coordinator, Murrell Dobbins Vocational School, Philadelphia, Pennsylvania*. Eighth Edition. Cloth. Pages viii+148. 13.5×21.5 cm. 1942. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price \$.50.

SEMIMICRO LABORATORY EXERCISES IN GENERAL CHEMISTRY, by J. Austin Burrows, Ph.D., *Professor of Chemistry*; Paul Arthur, Ph.D., *Assistant Professor of Chemistry*; and Otto M. Smith, Ph.D., *Professor of Chemistry and Chemical Engineering, all of Oklahoma Agricultural and Mechanical College*. Paper. Pages xiii+331. 20×28 cm. 1942. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price \$2.50.

MILITARY AND NAVAL MAPS AND GRIDS, by William W. Flexner, *Department of Mathematics, Cornell University*, and Gordon L. Walker, *Department of Mathematics, University of Delaware*. Paper. 96 pages. 14×21 cm. 1942. Price \$1.00.

THE EFFECTIVE USE AND PROPER CARE OF THE MICROTOME, by Oscar W. Richards, Ph.D., *Research Biologist*. Paper. 88 pages. 13×19.5 cm. 1942. Spencer Lens Company, Buffalo, N. Y. Price 25 cents.

AERONAUTICS WORKBOOK, by Cornelius H. Siemens, *Assistant Professor University of California, Berkeley, Calif. Educational Consultant, Civil Aeronautics Administration*. Paper. Pages iii+174. 18×27.5 cm. 1942. Ginn and Company, Statler Building, Boston, Mass. Price \$1.00.

AN ELEMENTARY COURSE IN QUALITATIVE ANALYSIS, by William Lloyd Evans, Jesse Erwin Day, and Alfred Benjamin Garrett, *The Ohio University*. Paper v+240. 19.5×26.5 cm. 1942. Ginn and Company, Statler Building, Boston, Mass. Price \$2.25.

THE USE OF TESTS AND RATING DEVICES IN THE APPRAISAL OF PERSONALITY, by Arthur E. Traxler. Educational Records Bulletin, No. 23 (Revised). Paper. Pages vii+74. 21×27.5 cm. 1942. Educational Records Bureau, 437 W. 59th Street, New York, N. Y.

BOOK REVIEWS

THE "PARTICLES" OF MODERN PHYSICS, by J. D. Stranathan, Professor of Physics, University of Kansas. Pp. 571+xvi, Figs. 211, 15½×23½. The Blakiston Company, Philadelphia, Pa. Price \$4.00.

Here is a book of a most pleasing format which immediately attracts and retains the interest of the scientist and bibliophile by the wealth of its material and the width of its scope. It is a book, which as its title indicates deals primarily with the problems of modern atomic and nuclear physics. This, however, is not done to the exclusion of classical physics. On the contrary, in it one finds a wealth of descriptive material and references pertaining to the early experiments from which our modern concepts have sprung. In fact, one of the most distinguishing characteristics of the book is the sense of complete continuity that one feels that exists between the classical and modern physics.

The beginner will find in it the foundation upon which the modern atomic physics rests and thus will be able to form a scientifically vigorous and historically compact and balanced picture of the recent developments in physics. Perhaps nothing can illustrate better the thoroughness of this book than the fact that in connection with the material discussed within a single page one will often find at the bottom of the page numerous references pertaining to research done over several decades. Since books dealing with the topics of modern physics perforce have not as yet been standardized in content it will not be amiss to give here the titles of the chapters. They are: Gaseous Ions and their Behavior; The Electron; The Electrical Discharge; Cathode Rays; The Ratio e/m for Electrons; Positive Rays; Isotopes; Photons; The Photoelectric Effect; X-Rays; Alpha, Beta and Gamma Rays; Natural Radioactivity; The Positron; The Neutron; Atomic Nuclei; Artificial Disintegration; Cosmic Rays; The Mesotron; and "Particles" or Waves.

From this simple enumeration of chapter titles the reader may obtain an idea of the breadth of the scope of this volume and the immensity of work and time that the author has put into it in the last fifteen years during which time the author used his notes in connection with his lectures in the field of modern physics to juniors, seniors and beginning graduate students at the University of Kansas.

Dr. Stranathan, in his preface, states that he hopes that the book will serve two purposes; first, that it will carry to the student early in his career many of the essential fundamental concepts of modern physics; second, that it will serve as a valuable reference book for the more advanced student. The writer, from the reading of selected topics believes that the author has succeeded in his difficult objective. The author balances admirably the theoretical and experimental points of view and his discussion of various, as yet, undecided theories remains free of the prejudices characteristic of the various schools of thought.

This volume, unquestionably, is an outstanding addition to the bibliography of modern physics and it will be extremely useful not only to the student, but also to the teacher, thanks to the abundance of references, historical notes and many diagrams which simplify the treatment and understanding of many physico-mathematical concepts. The book is artistically bound, well printed and enriched with an abundance of well-selected diagrams, photographs, tables and extensive author and subject indices. The writer regrets that the book does not include at the end of each chapter exercises and problems and he hopes that in a second edition or in a supplement this omission will be corrected.

It can unhesitatingly be stated that this book is a must in the library of every progressive student and teacher and that one who reads this book will be rewarded with a clearer and sounder view of modern physics.

PHILIP A. CONSTANTINIDES
Wright City College,
Chicago, Illinois

FUNDAMENTALS of RADIO, by Edward C. Jordon. *Instructor in Electrical Engineering, Ohio State University and Associate, Institute of Engineers; Paul H. Nelson, Assistant Professor of Electrical Engineering, The University of Connecticut; William Carl Osterbrock, Professor of Electrical Engineering, University of Cincinnati and Member of A.I.E.E. and I.R.E. Fred H. Pumphrey, Professor of Electrical Engineering, Rutgers University; Lynne C. Smeby, Director of Engineering for the National Association of Broadcasters and Member of the Board of Editors of The Institute of Radio Engineers.* Cloth. Pages xiii + 400. 15 × 23 cm. 1942. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price \$3.75.

The need for men trained in the radio field is now exceedingly great. Many high school graduates who must now enter the armed services must prepare to fill this demand. This book is designed to meet their needs. The first chapter is a review of the mathematics needed in the course. It consists of fundamental laws and process of algebra including quadratic equations, the fundamental processes of trigonometry, vectors, graphs, and logarithms. The second chapter gives the elementary ideas of high school electricity with particular emphasis on the facts to be used later in the radio circuits. These two chapters covering seventy-four pages are meant for a review of the high school mathematics and science and may be omitted by those with sufficient preparation. Chapter III gives the discussion of A.C. circuits needed for the radio theory. Most high school students who have had good elementary courses in mathematics and physics may start with this chapter and review the first two chapters as needed. Chapter IV gives the essentials of electronic principles and marks the point of departure for one who has had courses in electricity, both D.C. and A.C., but has not made a study of electron tubes. All of the remainder of the book, consisting of about 280 pages, is devoted to a thorough and practical treatment of radio circuits and instruments. The discussion is excellent throughout, the illustrations are carefully made and discussed, and the subject matter is sufficient to meet the needs of all practical workers. Of the many elementary books that have recently come out to supply the needs of radio men for the war, this one is by far the superior. Good high school physics students should find no difficulty in mastering the essentials of radio theory. Good students, without the essentials of physics, can master the fundamentals by careful study of the first three chapters.

G. W. W.

THE ELECTRICAL FUNDAMENTALS OF COMMUNICATION, by Arthur Lemuel Albert, M.S., E.E., *Professor of Communication Engineering, Oregon State College; Professor of Electrical Engineering, Purdue University (1942-1943)*). Cloth. Pages vii+554. 14.5×23 cm. 1942. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price \$3.50.

This book was written to provide the fundamentals of electricity to students in the three related divisions of telephony, telegraphy, and radio. The first four chapters cover the fundamental ideas of direct current as used in the communication fields. This section makes up about one-fifth of the book and may be omitted or used merely for reference by those who have mastered a high school course in electricity. Chapter V gives the fundamentals of alternating current theory and its vector representation. This covers material not usually given in the high school texts. This is followed by thorough discussions of the Magnetic Field and Inductance, the Electric Field and Capacitance, and a chapter on electric measuring instruments. These three chapters provide the proper information for a more complete consideration of sinusoidal waves which are now discussed. The algebraic treatment follows in which both the analytical and algebraic expression of vectors is explained and used, and finally the use of polar values is applied. The author is now ready for a complete analysis of electric net-works which is given in Chapter XI. A short chapter on bridge circuits gives the important uses of the bridge as applied in communication circuits. Three excellent chapters on The Transmission of Electromagnetic Waves, Fundamental Principle of Vacuum Tubes and Vacuum Tubes as Circuit Elements follow. Here the student should readily be able to grasp the complete significance of the main points of radio circuits. A short chapter on electroacoustics and tables of trigonometric functions complete the book. Each chapter is followed by a brief summary, a set of questions, and problems. The book has been carefully written, is mechanically perfect, and should meet the demand of the many students now needed in this field.

G. W. W.

INTRODUCTORY ORGANIC CHEMISTRY, by E. Wertheim, *Professor of Chemistry, University of Arkansas*. Cloth. Pages vii+482. 82 illustrations. 1942. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price \$3.00.

This text is designed to introduce organic chemistry to students in home economics, agriculture, medicine, and dentistry. As such it is to be recommended highly, since the author has made every effort to sell the subject by the use of colorful examples and statistics of general interest. The book is well illustrated with photographs of chemical products and also of molecular models of representative compounds such as propane, acetylene, and urea.

The last quarter of the text is an excellent presentation of animal metabolism and nutrition. The vitamins are particularly well handled and the comparative photographs of normal and deficient rats are quite striking. Another section of interest to nutrition students is the last chapter which discusses foods and dietary necessities. This section is supplemented by a complete table in the appendix on composition and the use of foods. In another portion of the appendix is a treatment on the removal of stains, which should be of use in textile courses.

One topic which has perhaps been under-emphasized in the text is that of plastics and polymers. There is no definite discussion which would serve to give the student an understanding of the chemistry of addition and condensation polymers, and the chemical differences between thermoplastic

and thermosetting types. This is a minor criticism, since plastics are mentioned in various parts of the book, but the reviewer feels that polymers have now become important enough industrially to warrant more attention.

The printing and binding of the textbook, in keeping with the subject matter, has been excellently executed.

ROBERT L. FRANK
University of Illinois

MAP READING AND AVIGATION, by Richard M. Field, *Princeton University* and Harlan T. Stetson, *Massachusetts Institute of Technology*. Cloth. Pages xii + 123. 84 illustrations and appendix of tables. 28.5 cm. × 22 cm. 1942. D. Van Nostrand Company Inc., 250 Fourth Avenue, New York City. Price \$2.50.

This is an introductory course in modern map reading and avigation suitable for the senior high school and college freshman. This compact book has the following outstanding features: excellent pictures, clear exercises and simple calculations, all of which are essential in the avigator's training. There is a very close intergration of pictures, models and topographic maps which aids the correct interpretation of the land features depicted. The importance of physiography to the avigator is indicated in the following quotation: "During the last war it was found that it was easier and quicker to teach an avigator how to visualize the terrain from a topographic map by teaching him the principles of physiography than by any other method." The book requires fifty-two hours in twenty-six laboratory-class periods to give training in the necessary simple essentials.

VILLA B. SMITH

AVIATION MATHEMATICS, by A. F. Buchan and R. Borthwick, *Squadron Commanders, City of Edinburg Wing*. American edition prepared by William R. Wadden, *Rindge Technical School, Cambridge, Mass.*, and Lt. Commander James G. Willett, *U.S.N.R.* Cloth, 143 pages, 1942. Houghton Mifflin Co., 2 Park St. Boston, Mass. 88 cents.

Of the many books and pamphlets assembled for the so-called "preflight" classes, this is by far the best I have seen. It is based on a text written by two Scottish squadron commanders, and is edited for American schools by a teacher in a technical school and a commander in the naval reserve.

The book contains: the fundamental operations in arithmetic, the Pythagorean theorem, ratios and proportions, signed numbers, formulas, linear equations, sets of equations, quadratic equations, the simpler geometric constructions, graphs, chapters on the compass, the triangle of velocities, logarithms, the slide rule, the law of sines and cosines, 10 pages of review examples, and 20 more pages of practice tests and other problems, answers to the problems, and the necessary tables. It is unfortunate that negative characteristics are written with a bar above the number, but that old-fashioned style is of slight importance compared to the excellence of the material.

The book is suitable for a one-semester course for pupils who have had a year of algebra and a year of geometry, or a year of general mathematics. The material may well be presented to boys in their last semester in high school before joining the armed forces, regardless of whether they join the aviation corps or some other branch of the services.

JOSEPH A. NYBERG
Hyde Park High School

THE STEEL SQUARE, by Noel D. Green, *Plant Engineer, Demolition and Construction, Ltd., London*. First American Edition, pages 88. 80 figures. 13.5×21.5 cm. Cloth. List Price \$2.50. Chemical Publishing Company, Inc. Brooklyn, N. Y. 1942.

The First American Edition of this text mentions in its preface that, "The steel square is to the carpenter what the slide rule is to the engineer—namely, a most valuable aid to rapid and accurate working." This unique comparison can more readily be appreciated by one conversant with carpentry and structural engineering. The author has assembled his material in progressive order with clear explanation in the uses of the Steel Square. The photographs and illustrations supplement the written material so that it can serve as a working manual. The text should facilitate in estimating timber requirements for flooring, shelving, sheathing, and partitioning. Tables in rear portion of the book furnish additional data for the use of the square. One is aware that quite a bit has been expressed within its 88 pages.

LUMIR P. BRAZDA
Wilson City College

AIR NAVIGATION, PART I AND PART II, by General Editor, E. Molloy, Cloth. Part I, pages viii+128. Part II, pages viii+132. 13.5×21.5 cm. 1942. Chemical Publishing Company, Inc., 234 King Street, Brooklyn. N. Y. Price each \$2.50.

These form volumes 22 and 23 of "Aeroplane Maintenance and Operation Series. According to the sub-titles, Part I, deals with air pilotage and dead reckoning, maps and charts, flying with the aid of instruments, astronomical and radio navigation, meteorology, and air navigators' licenses and regulations. Part II deals with magnetic compasses, navigational calculators, drift sights, sextants, directional radio systems and the use of radio beams. Since these are essentially the chapter headings, they summarize the content. An important point, not made clear by the title, is that the books are written from the British point of view, in fact one could reasonably conclude that they were designed for instruction in Great Britain. The discussion relates to British maps, British instruments, British weather, and British licenses. If this information is desired, no doubt these books are excellent, but it is doubtful if they would be considered the best texts for all courses in the United States.

The printing is not always as good as might be, and the illustrations are in some cases dull and hard to read clearly.

CECIL B. READ
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INTRODUCTORY COLLEGE CHEMISTRY, by Horace G. Deming, *Professor of Chemistry, University of Nebraska*. Second Edition, in collaboration with B. Clifford Hendricks, Professor of Chemistry, University of Nebraska. Pages xii+521. 15×24 cm. 1942. John Wiley and Sons, Inc., New York, N. Y. Price \$3.00.

This book, like the other Deming texts, is strikingly different from the usual textbook of general chemistry. The most pronounced difference, perhaps, is in the order of presentation of topics. This in some cases, necessitates a very unusual approach. Part I (169 pages) is devoted almost exclusively to principles. Two chapters on oxygen introduce a discussion of the nature of gases (kinetic theory) and of liquids and solids. Water is next discussed, following which (on page 78) symbols and formulas are introduced; the periodic table leads to a brief chapter on atomic structure, and

a discussion of the preparation and properties of acids serves to introduce the subject of hydrogen. Part I closes with a chapter on "Salts, Valence, Hydrolysis."

The non-metals and their compounds are studied in Part II (154 pages) in the order carbon, silicon, boron, nitrogen, sulfur, chlorine and the halogens. To the reviewer this arrangement seems illogical, as non-metallic properties appear most strikingly in the halogens, and diminish rapidly toward the center of the periodic table. Part III (101 pages) describes the metals—some of them too briefly. Lead, nickel and chromium each receive only a page, and the discussions of mercury, tin and manganese are even shorter. Part IV (49 pages) takes up the study of organic chemistry.

Some of the favorite topics of inorganic chemistry are given little prominence or are omitted entirely. There is no mention of the LeBlanc process for soda, and the mining of native sulfur is barely touched upon. The balancing of oxidation-reduction equations is relegated to an appendix. On the other hand, several topics which are usually discussed briefly, are emphasized in this book. Thus, titrations, normal solutions, buffers and indicators are discussed extensively, and there are complete chapters on the colloidal state and on fuels.

On the whole, this text will be found to be both interesting and teachable. It is addressed directly to the student, and there are several suggestions as to study methods. There is a large number of exercises at the end of each chapter (Chapter 8, for example, has 75). Some of these merely review the material of the chapter, some are thought questions, and some are numerical problems. The cuts and diagrams are numerous and well selected. There are no references for further reading.

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INTRODUCTION TO SEMIMICRO QUALITATIVE CHEMICAL ANALYSIS, by Louis J. Curtman, *Professor of Chemistry, Chairman of the Division of Qualitative Analysis, The City College—The College of the City of New York*. Cloth. Pages x+377. 13.5×21.5 cm. 1942. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price \$2.75.

Although semimicro qualitative analysis has received consideration in many of the recent texts, the present book appears to the reviewer to be worth consideration not only as a text but also as a reasonably comprehensive reference work dealing with qualitative analysis and the reactions of the cations and anions.

Physically, the text is divided into five major parts and an appendix, the presentation being in order: Part I. Theory; Part II. The Metal Ions and the Anions; Part III. Calculations; Part IV. Laboratory Work; and Part V. The Anions and the Complete Analysis of Mixtures.

The theoretical portion proceeds logically from simple considerations of atomic structure through types of linkages to the various aspects of solution theory. Such essential topics as ionic equilibria, complex ions and the uses of the coordination theory, "redox" reactions, half-reaction potentials, and the Brønsted-Lowry concept of acid-base behavior are given adequate treatment, but at no time does the presentation become difficult to follow.

The reactions of the cations are discussed in the sequence common to hydrogen sulfide procedures in the second portion of this text, particular stress being laid upon ionic reactions. The anions, of which only nineteen of the commonest are included, are discussed in a fashion similar to that employed for the cations. Three convenient anion groups, based upon pre-

precipitation from neutral or ammoniacal solution by means of barium chloride-calcium chloride mixture, precipitation from nitric acid solution by means of silver nitrate, or lack of precipitation by these reagents, are distinguished.

The section on calculations deals with the preparation of standard solutions and is followed by a comprehensive discussion, well illustrated with numerous diagrams and photographs, of semimicro technique and apparatus which introduces the student to the laboratory work.

The cations are studied through the use of preliminary experiments, and these are followed for each group by directions for the analyses of knowns and unknowns. For the anions, preliminary experiments are given, and then the systematic procedure for the detection of the anions and cations is given in detail. A welcome innovation is the detection of the anions prior to the detection of the cations in the systematic analysis.

Laboratory directions are clearly worded and should prove easy of application. The author has drawn freely upon his own wide experience and has introduced such procedures as the following: the use of potassium hydroxide in the sub-group division in group II, provision for the detection of arsenic not precipitated in group II, the removal of phosphate by means of zirconyl chloride, and the removal of interfering anions before the detection of the cations.

The teacher will also welcome the many problems appearing in the text, the repeated use of the ion-electron method for the balancing of equations, the references listed, and the useful data in the appendix. He will find, too, an attractively bound volume free from significant errors.

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GENERAL TRADE MATHEMATICS, by E. P. P. Van Leuven, *Department of Mechanical Arts, Kern County Union High School and Junior College, Bakersfield, California*. Cloth. 575 pages. 16×23 cm. 1942. McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, N. Y.

This book is an excellent text for students of the industrial age of today. It is general enough to cover educational requirements and specific enough to serve as a reference work to advanced students and artisans.

In the chapters covering general mathematics will be found topics that cover the fundamental principles of mathematics; numbers, fractions, rules and formulas, powers and roots, percentage, ratio and proportion, graphs, surface and volume measurement, and constructions. These topics are taken up in a progressive manner, and as the author states "written in a language the average boy can understand."

In the chapters dealing with specific trade training will be found the topics: direct instrument measurement, lumber measure, plastering and protective coating, pulley speeds and diameters, surface cutting speed, taper cutting, screw thread cutting and measurement, milling machine indexing, mechanics and mechanical powers, electricity and efficiency. These topics are approached from a purely mathematical viewpoint but with enough explanation to allow the student to see the significance of the problems.

The chapter on vocational finance covers the important social problems of the working man from piecework through social security and compensation insurance.

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PHYSICS FOR SECONDARY SCHOOLS, by Oscar W. Stewart, *Professor of Physics, University of Missouri*, and Burton L. Cushing, *Head of the Department of Sciences, East Boston High School and Lecturer on the Teaching of Physics at the Harvard Graduate School of Education*. Cloth. Pages viii + 745 + 15. 14 × 20 cm. 1942. Ginn and Company, Chicago, Ill. Price \$1.80.

This textbook is divided into thirty chapters grouped into six units, which are essentially mechanics, heat, electricity, sound, light, and radiation. It is well organized to meet the demands of a high school course. A brief topic on the mathematics used in physics could well be amplified for effectiveness. At the end of each chapter is a set of questions and two groups of problems, the second group giving those of a more technical nature. These provide plenty of flexibility in allowing for various types of students who take the course. The topics "For Investigation" at the end of each chapter give extra projects which, if carried out, will result in definite learning adjustments by the pupils.

The authors get away from the habit physics textbook writers have in putting some exceedingly dull remarks on ductility, malleability, and the inevitable impenetrability in the first chapter. But those who are disappointed in that will find the usual treatment on page 140.

The reviewer has always had an aversion toward having anyone refer to mass as "quantity of matter" but the authors do it in a subtle manner by saying "we must frequently measure the quantity of matter. The simplest way to do this is to measure the attraction the earth exerts on matter, called its weight, by means of a spring balance or a platform balance." Students may confuse density with mass if you call mass the quantity of matter.

The treatment in this textbook of centrifugal force is commendable and the reason for distinguishing between centripetal force and centrifugal force should be clear to all students. This should be one less place where a student after going to college has to unlearn something taught in high school physics. The inclusion of some new material, as far as high school textbooks are concerned, on Doctor Anderson's measurement of the speed of light at Harvard was refreshing, as is the section of atomic emissions which leads to a discussion of the cyclotron. The book is illustrated by many simple line drawings which are excellent.

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MODERN-LIFE SCIENCE, by Robert H. Carleton and Harry H. Williams. Cloth. Pages x + 650. 14.5 × 22.5 cm. 1942. J. B. Lippincott Company, Philadelphia. Price \$2.40.

This integrated physical science textbook was designed to meet the needs, and stimulate the interests, of those high school students who will in all probability not go to college. The authors assume that teachers who use the book will set up objectives in science teaching in terms of desirable changes in pupil behavior. The purpose of the book is to help make the objectives functional in the lives of boys and girls.

Following an introduction on scientific method and attitudes the text is divided into eight units, as follows: Fire, Fuels, and Heat; Power and Machines; The Sky; Weather and Climate; The Crust of the Earth; Materials for Construction; Light and Radiations; Sound. Each unit contains from two to five problems to be solved. Important concepts are in heavy type

as paragraph headings. Numerous questions are given for study and review of each problem. Each unit closes with application exercises for thought and discussion, a word list, a list of interesting things to do, topics for investigation and oral or written reports, and books for supplementary reading. An extensive index is provided. A separate activity manual containing demonstration and laboratory experiments will be available.

Photographs are recent and ample in number. Line drawings with a black background are used throughout. This new technique has great clarity and effectiveness in explaining machines, apparatus, electric circuits, the solar system, earth cross-sections, optical instruments, etc.

This text is not a diluted or popularized treatment of traditional subject matter. The content and activities suggested are such as to challenge all students.

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ELEMENTARY METEOROLOGY, by Vernor C. Finch, *Professor of Geography, University of Wisconsin*; Glen T. Trewartha, *Professor of Geography, University of Wisconsin*; M. H. Shearer, *Westport High School, Kansas City, Missouri*; and Frederick M. Caudle, *Assistant Professor and Coordinator, Civilian Pilot Training, University of Wisconsin*. Cloth. Pages v+294. 15×23 cm. 1942. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price \$1.76.

This is a high school text in meteorology that should receive the attention of all teachers introducing a course in that subject or pre-flight training. The first seven chapters (197 pages) are a reproduction of the opening chapters of Finch, Trewartha, and Shearer, *The Earth and Its Resources*, one of the better high school physical geographies. (Reviewed in *SCHOOL SCIENCE AND MATHEMATICS*, Vol. 41, October 1941, pages 702-703). This portion of the text follows the normal organization: the earth and its planetary relations, the weather elements, storms, and climate. Chapters eight and nine (72 pages) consider a practical application of the material: weather information for pilots and weather applications to aviation. The material contained in these last mentioned chapters has been supplied, at least in part, from the experiences of the fourth author, a United States Weather Bureau Meteorologist and a ground school director and instructor in the Civilian Pilot Training Program. These pages are a most welcome inclusion and one of the few successful attempts to present this type of material at the high school level.

The textual material is accurate, interestingly written, and, for the most part, recent. This no doubt reflects the scholarly ability of the senior authors. It is unfortunate, however, that the weather maps reproduced are not of recent date. The style of the maps published by the United States Weather Bureau and the information contained thereon have been changed considerably since 1940. I think that a text published in 1942 and attempting to use the most recent material available should have reproduced the type of weather map that is now being used. The student will probably have to use a current map for his daily information.

This book will serve the purposes of many of the pre-flight courses, will give an overall picture of meteorology and its application to aeronautics to those boys who will enter the air arms of our military and naval forces, and may also supply valuable information for those young people who will enter the widely expanding aviation industry after the war.

ALDEN CUTSHALL
University of Illinois

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